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PHYTOPLANKTON INVESTIGATIONS ON LAKE VELENCE (ALGAL COUNTS AND BIOMASS)

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On the basis of investigations of the number of algal individuals and of biomass, carried out at 13 points of Lake Velence in 1973—1974, three algologically different areas and, within them, transitional, or in some respects individual, water types can be distinguished in the Lake. The density of the plankton algae is extremely high in the NE sample sites; this is the region of planktonic eutrophication. In the SW areas of the Lake the algal density is low; as a result of the benthic eutrophication, it is not in the phytoplankton that the nutrients are incorporated. The trophication of the large open waters in the middle of the Lake is small; here the number of the phytoplanktonic individuals is between those of the former two areas, but there is no aquatic vegetation on the bottom. The differences in the values of the degree of algal proliferation, measured by means of the biomass, are not so extreme as those in the number of individuals. The ratio of the large-bodied species (*Peridiniopsis borgei* Lemm. and *Botryococcus braunii* Kütz) influences the biomass values; the species with a volume smaller than 100 μ^3 are significant only at a density of several million individuals as far as the changes in value are concerned.

It has been pointed out that in the algologically differentiated areas of the Lake, the species composition of the phytoplankton is also different.

Lake Velence lies at 47°13' of the Northern latitude and at 18°35' of the Eastern longitude in Hungary (LÁSZLÓFFY 1962). Its length is 10.54 km; average diameter 2.5 km; the area of the Lake is 25.28 km^2 at water level of 160 cm; the area of the water-surface is 10.30 km^2, that of the reeds is 14.98 km^2. The volume of the Lake is 41.16 mill.m^3, its medium depth is 1.62 cm (BARANYI 1972).

The general characteristic of the Lake are as follows:

— a natron lake rich in solved salts;

— a plant life very intensive in the whole lake; naturally eutrophic to a larger extent, artifically to a smaller extent;

— the water contains a great quantity of solved organic substances of natural origin (humic substances);

— the lake is a mosaic of several separate areas of water with different physical, chemical and biological parameters, hence areas of different water qualities.

The natron character of the lake and the development of the different water qualities of the various areas are a consequence of hydrological and biological causes. The tributary stream carrying the greatest quantity of water,

named Császár-viz; arrives in the reeds covering the SW part of the lake, and its water excess runs down the artificial overfall-weir built at a distance hardly 1 km from it, named Kajtor-canal.

The water of the brooks on the NE, however, never reaches the canal, because it evaporates. As a result, the lake has no outlet, one of its characteristics and an explanation of the accumulation of salt.

The mosaic structure of the lake is a result of the reeds and reed-walls subdividing the water surface into several parts where the waters of the greater or smaller clearings do not mix with each other. The different water qualities of these areas manifest themselves in addition to the different chemical compositions also in the remarkably different colours of the water. The water of the clearings, which are surrounded by reeds, had settled in a crystal-clean state since there is no considerable water movement in the lake; its colour has become stained brown by the decomposing, rotting organic substances produced during centuries in the reeds. The waters of these clearings are the so-called dark-brown waters. The great contiguous open water is less brown, always non-transparent, muddy, of grey colour, while in areas where the local contamination accelerates the proliferation of the algae, the water is pike-gray or it can be also greenish.

The aim of my paper is to separate on the basis of examinations of the number of algal individuals and the biomass, the algologically distinguishable areas of this mosaic-like lake, and to determine the temporary standing crop of the algae at the sampling sites.

As regards the quantitative conditions of the phytoplankton of the lake, there has been published only one paper (UNGER 1924), in which the author gave the quantitative data of a few species, unfortunately without an exact designation of the locality.

The methods of sample collecting and processing

The research workers of our Institute have been carrying out physiographical, botanical and chemical investigations in the lake since 1969 (their data are in the form of MSS, accessible in our Institute).

On the basis of their observations, we marked 13 sites for plankton examinations. These are in the order of enumeration given in Fig. 2, as follows:

No. 1. Lángi-tisztás
2. Vendel
3. Nagytó-Rigya
4. Gallér
5. Hosszú-tisztás
6. Nagy-tisztás
7. Belső-tisztás
8. Belső-tisztás
9. Felső-tó
10. Tizedes-tanya
11. Öreg-tisztás
12. Kárászos
13. Fürdető

The samplings were made on July 31, 1973, and on August 14, 1974.

For the quantitative examinations, we took 250 ml of water at each of the sampling sites from under the surface (at a depth of 30 cm). The collected material was fixed with lugol solution at the site (UTERMÖHL 1958), then it was treated with formalin and kept in a dark place until processing.

Counting was carried out from the aliquot portions of the samplings by means of the UTERMÖHL reversed microscope. The algae were counted along two diagonals perpendicular to each other, according to the method applied in hydrobiology, that is, counting always the number of algal individuals: the colonies the filaments and cenobies belonging together taken as one individual. The result was recalculated for one liter (i. $liter^{-1}$ = individuals per liter).

In the knowledge of the density of individuals per species, the biomass calculations were made. In the case of species whose body is similar to geometrical bodies, length, diameter and thickness were measured depending on the form of the cells, while in globular-shaped cells only diameter was measured. The data of 10–50 individuals were taken into consideration, and from the various calculated volume data the means were drawn. For the species occurring in colonies (*Gomphosphaeria*, *Coelastrum*, etc.), the number of the cells was also counted; from them an average was taken and multiplied by the volume values calculated for the cells. In the case of filaments, we did not count cells but considered the filament as a unit.
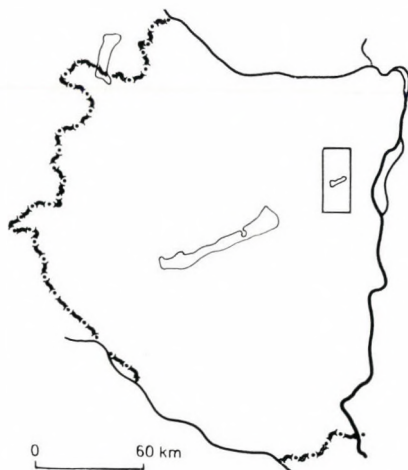
Fig. 1. West Hungary, with Lake Velence
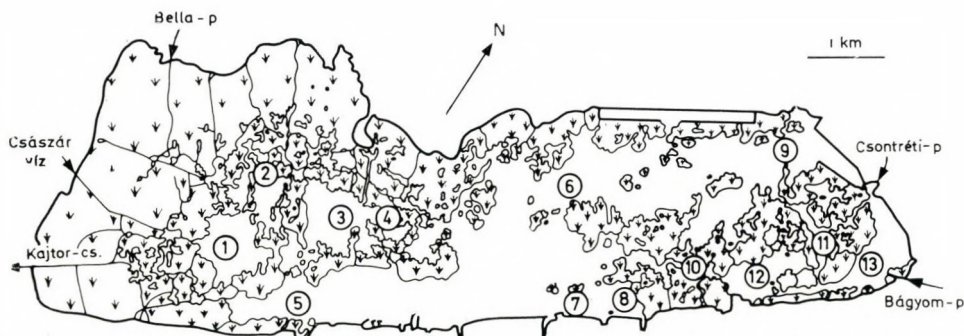
Fig. 2. Sampling places in Lake Velence

The various appendices, thorns (*Scenedesmus*) and the jelly-cover were disregarded.

The volume of some of the species can be calculated only by means of models; in such cases (6 species), the values used in the literature were taken into consideration (TAMÁS 1955; DUSSART 1966; BELLINGER 1974; WILLEN 1961).

Volume calculations did not extend to species represented by one speciemens or to those with a low population density. Since these species represented 1–10% of the number of phytoplankton individuals, their biomass was calculated so that as many percentages were added to the value obtained at the given sampling site.

The individual number of the non-calculated species; 1–5% at 4 sampling sites on the NE part of the Lake (Sampling sites Nos 10, 11, 12, 13) and 8–10% at the other sampling places. The volume data of the species:

Anabaenopsis hungarica	700 μ^3	
Aphanocapsa grevillei	1 400 μ^3	(cells 18)
Gomphosphaeria lacustris	200 μ^3	(cells 25)
Lyngbya limnetica	100 μ^3	
Merismopedia minima	0.3 μ^3	(cells 4)
Synechocystis salina	30 μ^3	(cells 2)
Goniochloris laevis	300 μ^3	
G. mutica	300 μ^3	
Chaetoceros mülleri	1 200 μ^3	
Cocconeis placentula var. *euglypta*	7 500 μ^3	
Cyclotella spp.	2 000 μ^3	
Nitschia spp.	600 μ^3	(TAMÁS 1955)
Cryptomonas erosa	3 800 μ^3	(WILLÉN 1961)
Peridiniopsis borgei	125 000 μ^3	
Ankistrodesmus pseudobraunii	20 μ^3	
Botryococcus braunii	10 000 μ^3	
Chodatella ciliata	2 100 μ^3	
C. citriformis	1 400 μ^3	
Coelastrum microporum	64 016 μ^3	(TAMÁS 1955, cells 16)
Cosmarium bioculatum	1 600 μ^3	
C. polygonatum	500 μ^3	
Cosmarium spp.	450 μ^3	
Crucigenia tetrapedia	80 μ^2	
Euastrum cornubiense var. *ornatum*	1 100 μ^3	
Oocystis spp.	900 μ^3	(BELLINGER 1974)
Pediastrum boryanum	3 800 μ^3	
P. tetras	2 270 μ^3	
Scenedesmus spp.	1 000 μ^3	(DUSSART 1966)
Tetraëdron caudatum	500 μ^3	
Tetraëdron minimum	100 μ^3	

Results

The results are summarized in Table 1. They do not contain the data of species represented only by a few specimens.

Changes in the numbers of the phytoplankton individuals

On the basis of the phytoplankton examinations, there are three algologically distinguishable areas in the Lake; within these, transitional-type waters, or such as are individual from some point of view, can to be distinguished. Therefore we discuss our results according to the distinct areas.

Table 1

Number of phytoplankton individuals and biomass in Lake Velence

		1		2		3		4		5		6		7		8		9		10		11		12		13	
		Lángi-tisztás		Vendel		Nagytó – Rigya		Gallér		Hosszú-tisztás		Nagy-tisztás		Belső-tisztás		Belső-tisztás		Felső-tó		Tizedes-tanya		Öreg-tisztás		Kárászos		Fürdető	
		i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}	i.ml^{-1}	mg.l^{-1}
CYANOPHYTA																											
Anabaenopsis hungarica Halász	VII. 1973.																	104	0.07	5240	3.66	42463	29.72	17724	12.40	58784	41.14
	VIII. 1974.											+		+				3152	2.20	7285	5.09	221400	154.98	66235	46.36	220108	154.07
Aphanocapsa grevillei (Hass.) Rabh.	VII. 1973.	193	0.27																								—
	VIII. 1974.																										—
Gomphosphaeria compacta (Lemm.) Strm.	VII. 1973.			62	0.03	59	0.02	15	0.00	6	0.00							282	0.14	+		+					—
	VIII. 1974.	+		+		237	0.11	+				178	0.08	297	0.14	81	0.04	713	0.35	+		+		+		+	—
Gomphosphaeria lacustris Chod.	VII. 1973.	505	0.10	62	0.01	59	0.01	14	0.00	9	0.00							163	0.03	185	0.03	+		+			—
	VIII. 1974.			+		89	0.01	+				193	0.03	195	0.03	148	0.02	431	0.08	+							—
Lyngbya limnetica Lemm.	VII. 1973.																	74	0.00	6466	0.64	77305	7.73	32472	3.24	147231	14.72
	VIII. 1974.																	9665	0.96	83257	8.32	269370	26.93	241326	24.13	307377	30.73
Merismopedia minima Beck.	VII. 1973.			+		+												+		260	0.00	+		+		1476	0.00
	VIII. 1974.			+		312	0.00	148	0.00											1189	0.00			1660	0.00	+	—
Synechocystis salina Wisl.	VII. 1973.			65	0.00	+																					
	VIII. 1974.	+		+				104	0.00									+									—
Other *Cyanophyta*	VII. 1973.			42		159				47		178		59				163		1152		1476		922		553	—
	VIII. 1974.	282		312		148		208		29		89		29				29		743		738		184		738	—
Cyanophyta total	VII. 1973.	698		231		277		29		62		178		59				786		13303		121244		51118		208044	—
	VIII. 1974.	282		312		786		460		29		460		521		229		13990		92474		491508		309405		528223	—
EUGLENOPHYTA total	VII. 1973.											17				37				37		184				553	—
	VIII. 1974.	44		14		29		89		5		178		89		89		89		74		369		184		369	—
CHRYSOPHYTA																											
Xanthophyceae																											
Goniochloris mutica (A. Braun) Fott	VII. 1973.	44	0.01	65	0.01	11	0.00	44	0.01	32	0.00	14	0.00			14	0.00	89	0.02	74	0.02			184	0.05		—
	VIII. 1974.			59	0.01	59	0.01	163	0.04	35	0.01	104	0.03			44	0.01	29	0.01	74	0.02	184	0.05				—
Goniochloris laevis Pascher	VII. 1973.													44	0.01												—
	VIII. 1974.	148	0.04											59	0.01												—
Bacillariophyceae																											
Chaetoceros mülleri Lemm.	VII. 1973.					+						+															—
	VIII. 1974.	74	0.08	74	0.08	624	0.74	1174	1.49	+				+		104	0.12										—
Cocconeis placentula var. *euglypta* (Ehr.) Cl.	VII. 1973.									35	0.26																—
	VIII. 1974.																										—
Cyclotella spp.	VII. 1973.					+								+		+		104	0.20	185	0.37						—
	VIII. 1974.	+		+				89	0.17					237	0.47	342	0.64	+		148	0.30	+		+		+	—
Nitzschia spp.	VII. 1973.													+						+		+				1476	0.88
	VIII. 1974.			+				+				+		+				+		1040	0.62	3505	2.10	1845	1.10	11254	6.75
Other *Bacillariophyceae*	VII. 1973.			5		17						14		59		14		29		111		184		297			—
	VIII. 1974.	14		29				29		11		14		89		29		178				369		369		184	—
Chrysophyta total	VII. 1973.	44		70		28		44		67		28		103		28		222		370		184		481		1476	—
	VIII. 1974.	236		162		683		1455		46		118		385		519		207		1262		4058		2214		11448	—
PYRROPHYTA																											
Cryptomonas erosa Ehr.	VIII. 1973.			113	0.42					+		+						+		185	0.70						—
	VII. 1974.	+		+				+				+		+						+		+					—
Peridiniopsis borgei Lemm.	VII. 1973.	42	5.25	157	19.62	169	21.12	193	24.12	148	18.5	63	8.00	342	42.75	96	12.00	+		408	51.00						—
	VIII. 1974.	133	16.72	89	11.15	505	63.17	148	18.58	249	31.22	624	78.06	356	44.61	371	46.46	639	79.92	+		+					—
Other *Pyrrophyta*	VII. 1973.	14						59		8		29		29		7		133		148							—
	VIII. 1974.	74		138		129		74		23		74		118		14				446		553		184		369	—
Pyrrophyta total	VII. 1973.	56		270		169		252		156		92		371		103		133		741							—
	VIII. 1974.	207		237		634		222		272		698		474		385		639		446		553		184		369	—
CHLOROPHYTA																											
Chlorophyceae																											
Ankistrodesmus pseudobraunii Belch. et Sw.	VII. 1973.																	252	0.00	3790	0.07	43542	0.87	21217	0.42	6642	0.13
	VIII. 1974.															89	0.00	1962	0.03	18807	0.37	38560	0.77	33948	0.67	32841	0.65
Botryococcus braunii Kütz.	VII. 1973.	+		+		41	0.41			+				+		+											—
	VIII. 1974.	238	2.37	163	1.63	89	0.89	+		95	0.95	+				+				+							—
Chodatella ciliata (Lagerh.) Lemm.	VII. 1973.	89	0.18	47	0.09	83	0.17	+		47	0.09	+		193	0.40	59	0.12	74	0.15	+				+			+
	VIII. 1974.	223	0.46	267	0.56	133	0.28	312	0.65	+		89	0.18	208	0.43	+		74	0.15								—
Chodatella citriformis Snow.	VII. 1973.																										—
	VIII. 1974.	148	0.20	+		89	0.12	89	0.12					+													—
Coelastrum microporum Naeg.	VII. 1973.	+						+				+		+		+		74	4.7			+		+			—
	VIII. 1974.	+				+		+								+				+							—
Crucigenia tetrapedia (Kirch.) W. et W.	VII. 1973.			+				+				89	0.00	+		+		193	0.01	222	0.01	+		+		+	—
	VIII. 1974.	+		+		+		+		+		+				+		+		371	0.02	+		+		+	—
Oocystis spp.	VII. 1973.	163	0.14	113	0.10	83	0.07	89	0.08	133	0.11	327	0.29	163	0.14	148	0.13	297	0.26	334	0.30	922	0.82	+		1291	1.16
	VIII. 1974.	252	0.22	312	0.28	267	0.24	520	0.46	208	0.18	252	0.22	654	0.58	327	0.29	401	0.36	371	0.33	+					—
Pediastrum boryanum (Turp.) Menegh.	VII. 1973.	+										14	0.05	104	0.39	+		74	0.28	260	0.98			+		+	—
	VIII 1974.	148	0.56	+		+						74	0.28	148	0.56	74	0.28	74	0.28	743	2.82	+		+		+	—
Pediastrum tetras (Ehr.) Ralfs.	VII. 1973.													+				74	0.16	706	1.60	1660	3.76	1107	2.51	2214	5.02
	VIII. 1974.	+										+		+		+		+				+				+	—
Scenedesmus acutus Meyen	VII. 1973.																	+		185	0.12	+		922	0.59	1291	0.83
	VIII. 1974.																	+		+		922	0.59			+	—
Scenedesmus ecornis (Ralfs.) Chod.	VII. 1973.	+						+				118	0.11	+		+		+		222	0.22	+					—
	VIII. 1974.					+		+				104	0.10	148	0.14	+											—
Scenedesmus quadricauda (Turp.) Bréb.	VII. 1973.	297	0.13			+				17	0.00	460	0.20	282	0.12	+		282	0.12	185	0.08	1107	0.49			6273	2.82
	VIII.-1974.																										—
Scenedesmus spinosus Chod.	VII. 1973.																			+		+		+			—
	VIII. 1974.											5															—
Scenedesmus spp.	VII. 1973.			+				+						475	0.11	156	0.03	862	0.21	4124	1.03	3321	0.83	7933	1.98		—
	VIII. 1974.	1323	0.33	89	0.02	341	0.08	416	0.10	+		639	0.15	484	0.12	609	0.15	1308	0.32	5575	1.39	6273	1.56	7749	1.93	7011	1.75
Tetraëdron caudatum (Corda) Hansg.	VII. 1973.	+										+		+				+		+				+		+	—
	VIII. 1974.	104	0.05					+				+		+				+		+		+				+	—
Tetraëdron minimum (A. Br.) Hansg.	VII. 1973.	1026	0.10	148	0.01	83	0.00	118	0.01	92	0.00	565	0.05	550	0.05	275	0.02	505	0.05	743	0.07	+		1476	0.14	1476	0.14
	VIII. 1974.	1472	0.14	193	0.01	1114	0.11	1159	0.11	196	0.01	505	0.05	862	0.08	565	0.05	490	0.04	1263	0.12	+		1476	0.14	922	0.09
Other *Chlorophyceae*	VII. 1973.	163		166		77		133		44		297		267		148		396		817		4428		3136		4797	—
	VIII. 1974.	252		148		312		267		65		89		297		252		223		892		3505		291		2583	—
Conjugatophyceae																											
Cosmarium bioculatum Bréb.	VII. 1973.											104	0.16														—
	VIII. 1974.																										—
Cosmarium polygonatum Halász	VII. 1973.	148	0.07	+		41	0.02					89	0.04											+			—
	VIII. 1974.																										—
Cosmarium spp.	VII. 1973.			29	0.01	41	0.01	+		121	0.05	+		77	0.03	44	0.01	609	0.27	1114	0.50	+		+		+	—
	VIII. 1974.	193	0.04	+		936	0.42	669	0.30	65	0.02	401	0.18	1011	0.45	416	0.18	282	0.12	+		+		+			—
Euastrum cornubiense var. *ornatum* Halász	VII. 1973.					+				47	0.34																—
	VIII. 1974.									+																	—
Chlorophyta total	VII. 1973.	1886		503		449		340		501		2057		2138		838		3652		12702		54980		35791		23984	—
	VIII. 1974.	4353		1172		3281		3432		629		2153		3812		2332		4814		28022		49260		44464		43357	—
Algae total	VII. 1973.	2684		1071		923		665		786		2195		2671		1006		4793		27153		176592		87390		234057	—
	VIII. 1974.	5123		1897		5413		5495		981		3607		5281		3554		19739		122278		545748		356451		583766	—
Biomass total	VII. 1973.		6.76		23.22		24.62		25.93		21.82		10.20		49.53		20.54		6.67		66.35		45.57		22.38		68.21
	VIII. 1974		23.87		15.55		72.84		24.18		35.66		87.36		53.29		53.11		89.12		19.20		188.82		75.41		196.01

It can be observed fairly well in Figs 3 and 4 that the algal density in the NE part of the Lake (sampling places Nos. 10, 11, 12, 13), in comparison with the other areas, is very high. In 1973, in these parts the number of algae was between 27 and 234 millions, in 1974 between 120 and 580 millions, per liter. In these places of the Lake, the plant nutrients manifest themselves in algae; we call this phenomenon, after LAKATOS, planktonic eutrophication (LAKATOS 1974). At the same time, at the SW end of the Lake (sampling places Nos 1, 2, 3, 4, 5) merely a five hundredth part of the former values were to be obtained, indeed in the deep unstirred water of the rowing track on the Hosszú-tisztás (No. 5), the density of algal individuals did not reach even a million. In these places the nutrients are incorporated in seaweed plants and filamentous algal swards (*Vaucheria dichotoma* Ag.); the phenomenon is called, after LAKATOS, benthic eutrophication (LAKATOS 1974).

These bottom-dwelling plants stabilize the plant nutrients in their body, hence in the water space above them the number of phytoplankton individual does not, in most cases, reach even 1 million ind. lit.$^{-1}$.

The so-called "great open water" is in the middle part of the Lake (sampling places Nos 6, 7, 8, 9). Sampling place No. 6 is the least productive part of the Lake, since the density of its phytoplankton individuals does not rise above 3 million ind. lit.$^{-1}$, even though no large-sized aquatic plant or filamentous algae are to be found in it. Sampling place No. 9 is undoubtedly the richest in algae among the larger northern clearings (5—19 million ind. lit.$^{-1}$), still its values lag behind those of the phytoplankton individuals of the NE waters (Nos 11 and 13), because the careful management of the Lake prevented its direct contact with the most eutrophic water of sampling site No. 13 (Fürdető) by heaps of stones and by leaving the natural reed wall intact. Nevertheless, the closeness of the Fürdető (No. 13) makes its influence felt in the species composition.

At the two sampling places of the Belső-tisztás (Nos. 7 and 8), we noted only a small difference. In the SW part (No. 7), the density of the algal individuals was 2—5 million ind. liter^{-1}, while in the NE part (No. 8), it was 1—3 million ind. liter^{-1}. In the latter sampling place, however, there was a considerable *Vaucheria dichotoma* stand on the bottom.

On the basis of species composition and density of the algal individuals, we relegated sampling place No. 10 (Tizedes-tanya) to the strongly eutrophic NE waters, No. 4 (Gallér) to the dark brown SW waters, but we must note that both of them are made individual by *Aphanothece bullosa* (Menegh.) Rabh., the benthic blue-green alga growing there in enormous masses.

In 1974, in comparison with 1973, the number of algal individuals increased in the whole area of the Lake, which is probably explainable by the more favourable weather conditions and by the low level of water. The density ratios described in the foregoing paragraphs, which are characteristic of the
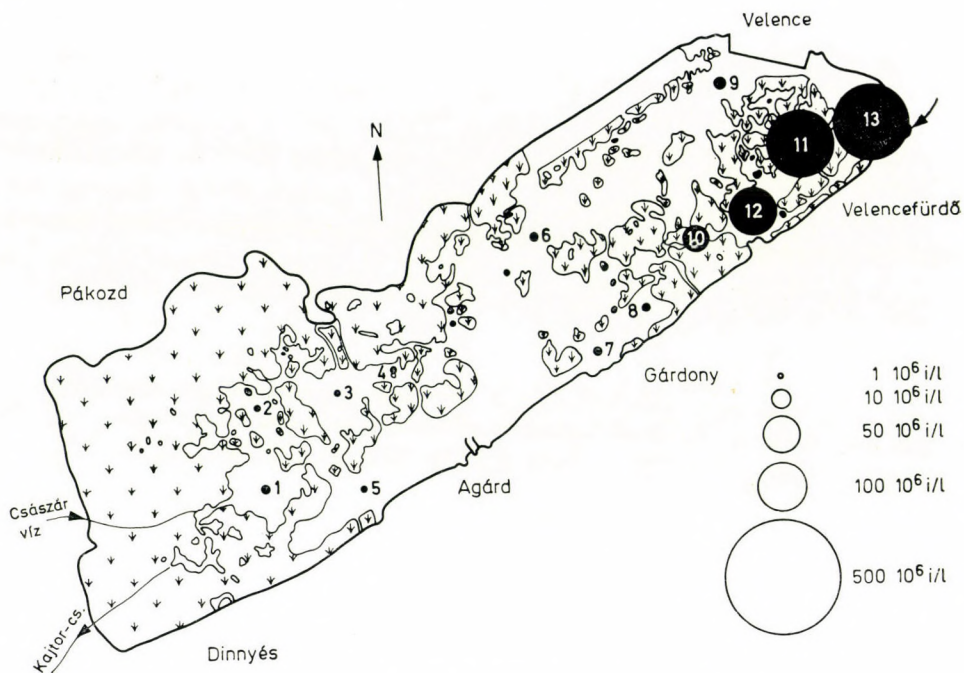
Fig. 3. Number of phytoplankton individuals in July, 1973
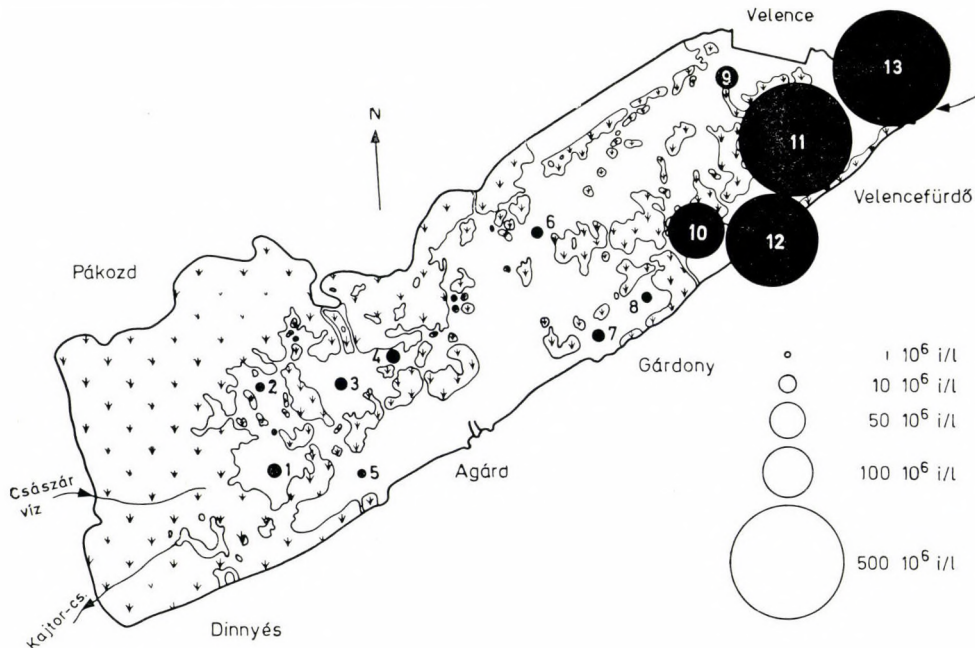
Fig. 4. Number of phytoplankton individuals in July, 1974

various water quality areas, remained unchanged. Exceptions to this were sampling places No. 1 (Lángi-tisztás) and No. 3 (Nagytó-Rigya). In sampling place No. 3, the *Vaucheria dichotoma* sward did not develop in 1974, so the nutrients were used by the phytoplankton; while in 1973 the number of plankton algae was 900 thousand ind. lit.$^{-1}$ here, in 1974 it increased to 5 million ind. lit.$^{-1}$. At sampling place No. 1, on the other hand, the increase in the number of algal individuals was exceptable. Since the introduction in 1969 of the Császár stream, that is, the elimination of the natural hemming by reed, this clearing gradually becomes eutrophized, and changes are noticeable also in its species composition, a consequence of the vegetable nutrients arriving through the stream.

By examining the distribution conditions of the species occurring in greater numbers of individuals, we may state that the appearance of part of the species is related to the various water quality areas. The following species persist, for example, the strongly eutrophic NE areas (Nos 10, 11, 12, 13): *Anabaenopsis hungarica* Halász, *Lyngbya limnetica* Lemm., *Ankistrodesmus pseudobraunii* Belch et Sw., *Pediastrum tetras* (Ehr.) Ralfs., *Scenedesmus acutus* Meyen.

The characteristic species of the SW sampling places (Nos 1, 2, 3, 4, 5) are: *Synechocystis salina* Wisl., *Chodatella citriformis* Snow, *Euastrum cornubiense* var. *ornatum* Halász, *Cosmarium polygonatum* Halász. The diatom *Chaetoceros mülleri* Lemm., which in 1973 occurred sporadically, appeared in a great number of individuals in the SW areas in 1974, its specimens could, however, be observed even in the great open waters (Nos 6, 7, 8).

Botryococcus braunii Kütz. is also a characteristic species mainly of the SW waters. The great open water (Nos 6, 7, 8) also has its characteristic organisms, which in the other areas occur sporadically at most. Such are *Scenedesmus ecornis* (Ralfs.) Chod., *Gomphosphaeria lacustris* Chod., *G. compacta* (Lemm.) Strm., and *Pediastrum boryanum* (Turp.) Menegh. The latter 3 organisms occurred in a greater quantity — besides the great open waters — in the Lángi-tisztás (No. 1), which is an indication of the gradual transformation and of different nutrient supply of this clearing; we have already pointed out its cause. *Gomphosphaeria lacustris* Chod. appeared in a greater quantity in the middle part of the Lake in 1974. We are glad to observe its spread in Lake Velence, because it is a proof of the formation of good-quality water.

Part of the species occurred in the great open waters and the dark-brown SW waters as well, but they were missing from the strongly eutrophic waters of sampling places Nos 11, 12 and 13. To this group belong *Peridiniopsis borgei* Lemm., *Cryptomonas erosa* Ehr., *Chodatella ciliata* (Lagerh.) Lemm. and some *Cosmarium* species.

For the sake of completeness, I mention the generally distributed species of large-scale tolerance: *Goniochloris mutica* (A. Braun) Fott, *Crucigenia*

tetrapedia (Kirch.) W. et W., *Tetraëdron minimum* (A. Braun) Hansg., and a great part of the *Oocystis* and *Scenedesmus* species.

We can already state on the basis of our present examinations, that the characteristic habitats of Lake Velence have a special algal flora. It is desirable that future researches be extended also the species which occur in only a few specimens.

Examination of the biomass of the phytoplankton

If we examine the biomass of the plankton algae, the extreme differences experienced in the case of algal density in the various parts of the Lake lessen (Figs 5—6). In 1973, the biomass values changed between 6.67 and 68.2 mg.liter^{-1}, while in 1974, similarly as in the case of the number of individuals, biomass also increased considerably; it varied between 15.5 and 196 mg/lit.$^{-1}$. The differences between the various water-quality areas in 1973 were 30 times the values of one another, while in 1974 they were 12.5 times that; this in comparison with the values 200 times and 500 times higher, obtained in respect of the number of individuals, is low.

The values measured at the given sampling places were extremely variable, depending on the size of the dominant algae. The biomass of the NE lake areas with extremely high density of individuals is in comparison with the number of individuals low, since in these sampling places 90% of the phytoplankton is constituted by *Anabaenopsis hungarica* Halász, *Lyngbya limnetica* Lemm., *Ankistrodesmus pseudobraunii* Belch, et Sw. Among these species the biomass of only *Anabaenopsis hungarica* is considerable (700 μ^3/filament).

It is worthy of attention that in 1974, at sampling places Nos 3 and 4, the number of algal individuals considerably increased, with a more significant increase in the biomass. At sampling place No. 3, the biomass increased to 3 times of its original value, while the number of algal individuals increased to more than 5 times of its original. At the same time, at sampling place No. 4, the increase of the number of individuals to eight times of its original value resulted in a decrease in the biomass. The phenomenon can be explained only in the exact knowledge of species and the number of their individuals, therefore it is important that at least the species which occur in greater quantities, and their volume, should be determined. A considerable part of the increase in the number of individuals, at both of the sampling places, occurred in the following organisms: *Merismopedia minima* Beck., *Goniochloris mutica* (A. Br.) Fott, *Chaetoceros mülleri* Lemm., *Chodatella ciliata* (Lagerh.) Lemm., *C. citriformis* Snow., *Tetraëdron minimum* (A. Br.) Hansg., *Cosmarium*, *Oocystis* and *Scenedesmus* species. These species hardly represent any biomass values. For example, the increase to 300 000 individuals in *Merismopedia minima* Beck.
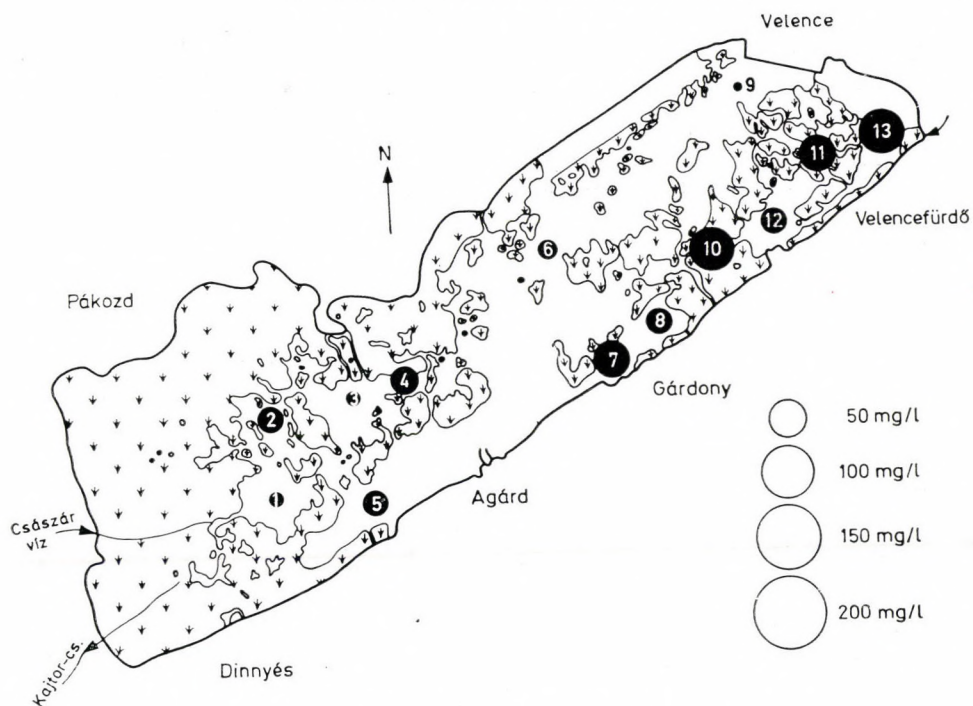
Fig. 5. Biomass of phytoplankton, July, 1973
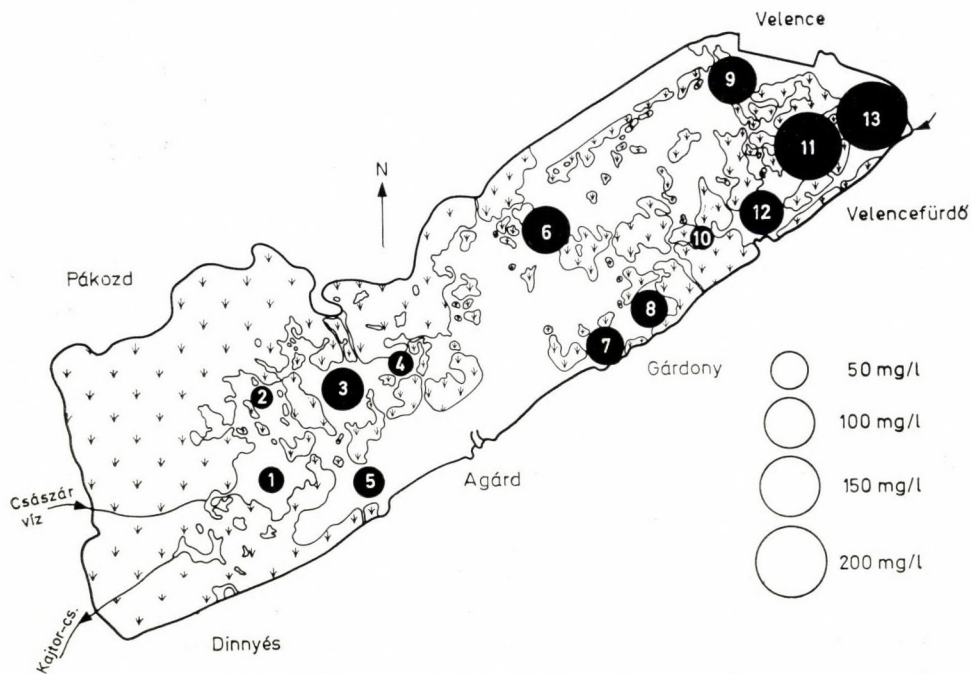
Fig. 6. Biomass of phytoplankton, August, 1974

results, owing to its small measures, in a 0.001 mg/l increase, which is practically negligible. The causes of the differences are the large-sized organisms, in the present case *Peridinopsis borgei* Lemm. (125 000 μ^3) and *Botryococcus braunii* Kütz. (10 000 μ^3). At sampling place No. 3 (Nagytó-Rigya), the number of algal individuals in *Peridiniopsis* increased three times to its original value, which means 42 mg.lit.$^{-1}$ in biomass. At sampling place No. 4 on the other hand, the number of individuals of *Peridiniopsis* decreased by 50 000, which resulted in a 6 mg.lit.$^{-1}$ biomass decrease; *Botryococcus* was represented only by 1—2 specimens in the samples.

In the Lángi-tisztás (No. 1), the 300 000 increase in the number of individuals of the two species mentioned above resulted in a 13 mg.lit.$^{-1}$ biomass increase, while the 2.2 million ind. lit.$^{-1}$ increase in the number of individuals was caused by green algal species whose the biomass was merely 3.4 mg.lit.$^{-1}$.

Either the increase or the decrease in the biomass at Vendel (No. 2), Hosszú-tisztás (No. 5), and the great open water (Nos 6, 7 and 8), is influenced by the increase or decrease in the number of *Peridiniopsis* individuals. At the same time, in the NE part of the Lake (Nos 11, 12, 13), the species composition was identical in both years, thus the 1974 increase in the biomass of this area is proportional with the increase in the number of individuals.

From the above examples it can be seen that the biomass values are primarily influenced by the ratio of the large-bodied species (in the case of the Lake Velence, mainly by *Peridiniopsis borgei* Lemm.).

In the course of examinations, we have established that algae with a smaller volume than 100 μ^3 are considerable, from the view-point of estimating biomass, only in the case of extremely great numbers of individuals. *Lyngbya limnetica* (100 μ^3) can be mentioned as an example, this alga represents only 0.1 mg/l biomass in the case of a 1 mill. lit.$^{-1}$ number of individuals. Therefore, in the knowledge of the species and the number of individuals in the sampling area examined, we can predict the species whose volume is worthy to calculate with great accuracy for the given water type, and which may considerably influence changes in biomass values.

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ECO-PHYSIOLOGICAL STUDIES ON HALOPHYTES IN ARID AND SEMI-ARID ZONES

I. AUTECOLOGY OF THE SALT-SECRETING HALOPHYTE LIMONIASTRUM MONOPETALUM (L.) BOISS.

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The present study is the first part of a series on the eco-physiology of halophytes in arid and semi-arid zones. An account of the salines and halophytes in Egypt is given in this part. *Limoniastrum monopetalum* is a salt-secreting halophyte growing in the Western Mediterranean coastal zone of Egypt, an area with attenuated sub-desert climate. Though the plant grows in different habitats as regards soil salinity, it dominates a community in the less-saline habitats with deep sandy soil. The plant, being endowed with special characteristics, has the potential ability to form mounds. The formation of mounds has many ecological consequences through its effect on the water plant and soil relationships. The mound formation goes hand in hand with the growth of the plant till the mound reaches a considerable size with a height of 50 cm or more. Two types of adventitious roots are produced due to mound formation: tufts of fine short roots and long fibrous roots; both contribute considerably to water intake by the plant. The plant has two distinct types of glands, differing as regards their distribution on the plant body, structure and function. These are the salt (chalk) glands and the mucilage glands. The salt-secreting glands are present on the leaves and young shoots; each is composed of 16 cells comprising 12 secretory cells and 4 subsidiary cells. Mucilage glands occur at the extreme base of the leaf sheath, on the upper epidermis each consists of a varying number of cells and is enclosed by large nonsecreting subsidiary cells.

Introduction

Salines occupy vast areas in the arid and semiarid zone and the problems of salinity are aggravated by the inadequancy of rainfall to remove the salts. However, salines are not entirely limited to such zones and halophytes are widely distributed in various climatic regions. Halophytes exhibit taxonomical and behavioural uniformity in the different regions, the same genus or even the same species may occur in different climatic regions. Environmental conditions prevailing in salines of the arid and semi-arid zones are very complex. The plants growing in these salines are subjected to severe climatic and edaphic aridity, in addition to physiological drought (Schimper, 1903) which is a common phenomenon in salines of different climatic regions.

Our knowledge of the eco-physiology of halophytes in arid and semi-arid zones is extremely limited. This and the subsequent papers represent an attempt to fill some gaps in our knowledge. Though the number of halophytic species is low compared to that of other groups of the flora of arid and semi-

arid zones, they contribute in a great measure to the vegetation of vast areas in these zones.

The present study deals with the autecology of a salt-secreting halophyte, namely *Limoniastrum monopetalum*. It represents the basis for the subsequent parts concerning the same species and dealing with aspects of its eco-physiology. An introductory part on the salines and halophytes in Egypt is given in this part.

Salines in Egypt

The desert occupies almost 97% of the total area of Egypt. Other than the salines occupying the northern part of the Delta and many parts of the cultivated areas, there are inland salines in the desert area and coastal salines along the Mediterranean and Red Seas.

Inland salines

Inland salines include the following series:

a) Erosion pavements with gypseous deposits. This type belongs to automorphous salines (ZOHARY 1962) and supports almost no vegetation.

b) Saline depressions in the desert and special habitats in the wadis which receive runoff water with dissolved salts. In rainy years, these salines are usually flooded with water, but the salinity increases at the upper layers in the dry season. Xerohalophytes as *Tamarix* spp., *Zygophyllum album*, *Atriplex halimus* and *Nitraria retusa* inhabit these salines.

c) Salines in the terminal drainage basins which occur in the deltaic plains of wadis of the Eastern Desert (KASSAS and ZAHRAN 1967) and the Sinai (MIGAHID et al., 1959). *Tamarix* spp. are of common occurrence in these salines.

d) Salines around springs and water points. Evaporation of the brackish or saline water leads to salinization of the habitat. Usually, hygrophilous plants grow near the source and halophilous plants grow removed from it. *Juncus* spp. are among the plants that grow in the salinized zone around these water points.

e) Salt marshes and saline habitats in the oases of the Western (Lybian) Desert (MIGAHID et al., 1960).

Coastal salines

A. Coastal salt marshes in the Mediterranean zone include
   a) Coastal swamps with very poor vegetation and a low number of species.
   b) Depressions to the south of the coastal dune belt, locally rather close to the sea level. Different halophilous plant communities inhabit these parts (TADROS 1953).
   c) Salt marshes occupying the western extension of Lake Mareotis and located between two limestone ridges extending parallel to the Mediterranean (TADROS 1953).

B. Red Sea littoral salt marshes, extending almost 1100 km from Suez to the Egyptian-Sudanese border in the south. Plant communities in these marshes were studied by (KASSAS and ZAHRAN 1967).

Halophytes in Egypt

The Egyptian flora comprises about 2300 species; out of these there are almost 80 terrestial halophytic species belonging to 31 genera and 17 families. Though the number of halophytic species is low, they constitute the vegetation of wide areas in the country. Classification of the halophytes in Egypt is not an easy task owing to the lack of knowledge about their biology, physiology and other aspects. Several attempts have been made to classify the halo-

phytic species (STOCKER 1928, STEINER 1935; IVERSON 1936, VAN EIJK 1939; TSOPA 1939; HENKEL and SHOKHOV 1945; CHAPMAN 1946; ADRIANI 1956 and WAISEL 1972).

Application of the classifications adopted by any of the above-mentioned authors to the halophytes in Egypt can not be achieved except after a thorough study of different aspects of their eco-physiology. In general, halophytes in Egypt may be classified provisionally into salt-secreting, succulent, and non-succulent halophytes.

Salt-secreting halophytes are represented by almost 30 species in the Egyptian flora. The species under study, *Limoniastrum monopetalum*, is one of these plants (BATANOUNY 1973). Succulents are represented by 28 species, the majority of which are chenopeds. Non-succulents include some plants which accumulate salts in some parts of their bodies, which are shed when the salts reach a high level, e.g. *Juncus* spp.

The species studied

Limoniastrum monopetalum is a shrublet with a whitish grey aspect belonging to the family *Plumbaginaceae*. Its stiff, narrow, spatulate leaves and the young branches are densely beset with white, calcareous tubercles. It is the only representative species of the genus *Limoniastrum* Fohr in Egypt. The plant dominates in a community inhabiting deep sandy soils; though it grows in highly saline soils yet with a low cover value. The plant has a limited geographical distribution in areas along the Western Mediterranean coastal zone in Egypt. The main associates growing in the community dominated by the species studied are: *Salsola tetrandra*, *Suaeda pruinosa*, *Anabasis articulata*, *Thymelaea hirsuta* and *Asphodelus microcarpus*.

Climatic conditions

The climatic conditions prevailing in the habitat supporting the plant studied may be summarized from the climatic data obtained by the El Dabaa Meteorological Station, located along the Western Mediterranean coast. The annual rainfall is 142.6 mm; a value that decreases rapidly as one proceeds inland. *L. monopetalum* is restricted to patches near the coast. The rainless period extends from May to August, and the rainfall is negligible in April, May and September. The rainiest months are December (41.8 mm), November (30.7 mm) and January (26.4 mm). The temperature conditions are mild, with a monthly mean ranging from 12.8 °C in January to 25.6 °C in August. The highest mean maximum is 30.0 °C in August and the lowest mean minimum is 7.0 °C in January. Absolute records show that the highest maximum is 43.8 °C in June and 0.0 °C in January; such values are of rare occurrence. The relative humidity tends to be higher in summer than in winter, a phenomenon observed by other investigators at different stations in the same zone (MIGAHID et al., 1971). It exhibits wide diurnal and seasonal fluctuations. Evaporation ranges from 3.9 mm/day in December to 7.2 mm/day in July. The area has an attenuated subdesertic climate (UNESCO/FAO maps, 1963).

Edaphic conditions

Mound formation

The edaphic conditions prevailing in the habitat supporting *L. monopetalum* are closely related to the formation of mounds by this plant. *L. monopetalum* is an effective soil builder and efficient soil conserver against wind blowing and flood streams. It has the potential ability to form mounds, being endowed by the following characteristics: ability to produce adventitious roots from buried vegetative organs, capability of producing new shoots replacing those buried by onblowing sand (in the possession of shoots having buds close or near the ground surface), and having an intricately branching shoot system. Huge mounds (Fig. 1) with an average height of 50 cm are formed by the plant studied as well as by other associates, as *Salsola tetrandra* and *Suaeda pruinosa*. Mound formation has many ecological consequences through its effect on plant-water and soil relationships.

In the seedling stage, the plant grows on the level ground without any sand accumulation, then the growth of the plant results in the accumulation of wind-blown and/or water-borne material forming a hillock rising above the ground level (Fig. 1). These hillocks are augmentative up to a certain limit, depending on a number of factors (BATANOUNY and BATANOUNY, 1968 & 1969).

Fig. 1. A profile in the mound body formed by *Limoniastrum monopetalum*

The growth of the plant helps stabilizing the soil. Its preponderance is an indicator of salinity reduction and an increased depth of the water table. Coalescence of the mounds leads to the elevation of the ground level and the consequent decrease in salinity. The community dominated by *L. monopetalum* may be considered the last stage of the halosere in the salt marsh communities along the Western Mediterranean coast in Egypt.

Soil characteristics

Though the plant studied grows and dominates in a community in habitats with soils having a low salt content, it grows — but with a low cover value — in highly saline soils. The soil study was carried out in two habitats: a less-saline habitat where *Limoniastrum* is the dominant plant, and a highly-saline habitat where the plant grows but is not dominating the plant cover.

a) *Penetrability*

Soil penetrability was studied by the use of Zaghloul's stratometer (Zaghloul, 1928), a method adapted by many investigators (Batanouny and Zaki, 1969). The wider the distance between the successive lines in the drawing, the more is the soil penetrability. It is clear from Fig. 2 that the soils forming the mound body and below it are more easily penetrable than those between the mounds. The mound body has more loose soil than that below it. On the other hand, in the highly-saline habitat the soil is easily penetrable in all sites. Soil layers near the water table and below it are easily penetrable in this habitat.

b) *Soil texture*

Soil forming the mound body is more fine-textured than soils below the mounds or between them (Table 1). The newly trapped soil material, forming the mound body, countains considerable amounts of silt and clay, ranging from 33 to 49%, while the coarse sand content is low, ranging from 12 to 15%. Below the mound body and between the mounds, the silt and clay content is low, ranging from 10 to 26%, and the coarse sand content ranges from 25 to 57% at the different depths.

c) *Moisture equivalent*

A remarkable difference can be observed between the moisture equivalent values in the mound body, below it, and between the mounds (Table 1). The soil forming the mound body has moisture equivalent values (10.80 to 12.08%) higher than those below (5.74—8.38%) and between the mounds (4.01—5.01%).
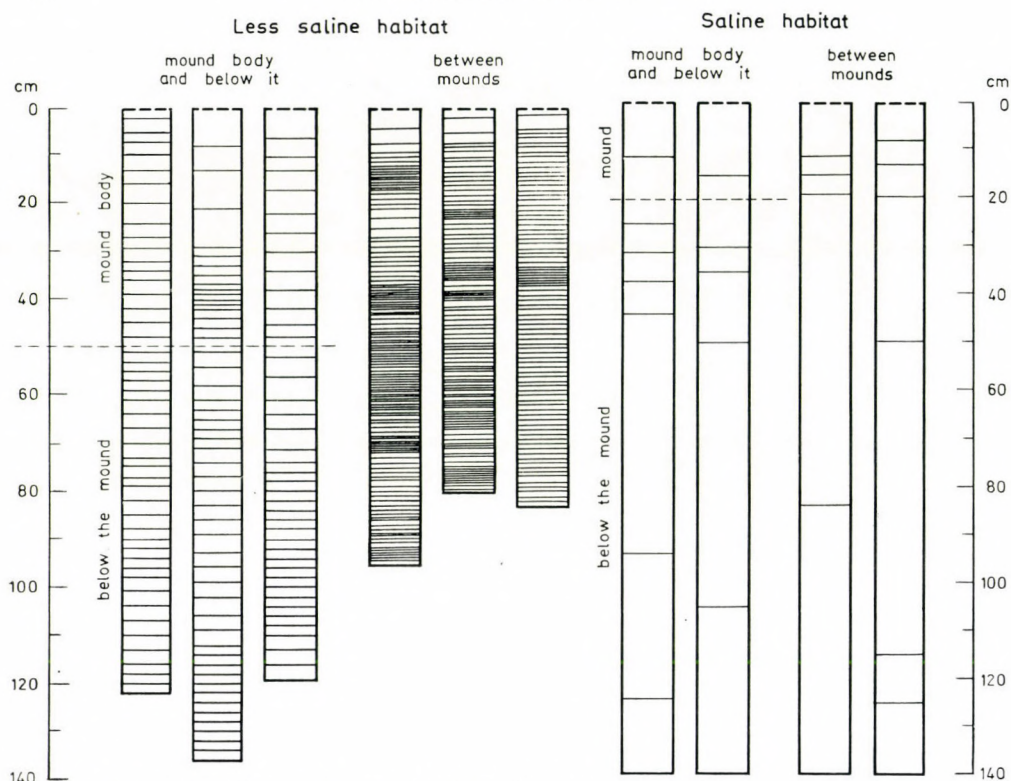
Fig. 2. Soil penetrability in the mound body, below it and between the mounds in two different habitats

Table 1

Granulometric analysis, moisture equivalent and hygroscopic water in summer, and soil moisture content in different months of soil samples collected at successive depths in the mound body, below it and between the mounds in the less-saline habitat

Site	Depth (cm)	Granulometric analysis			Moisture equivalent %	Hygroscopic water (%)	Soil moisture content (%)			
		Coarse sand %	Fine sand (%)	Silt & clay %			January	March	July	September
Mound body	0— 5	12	55	33	12.08	2.16	2.5	1.8	1.5	1.2
	5— 20	12	49	39	11.10	2.07	5.7	3.7	2.9	1.6
	20— 50	15	36	49	10.80	2.03	2.3	3.8	3.2	2.1
Below the mound	0— 25	25	57	18	8.38	1.72	1.6	3.4	1.7	1.4
	25— 50	33	45	22	8.26	1.63	8.7	7.0	6.8	4.1
	50— 75	49	36	15	6.01	1.66	14.4	9.0	9.2	4.3
	75—100	57	33	10	5.74	1.56	9.6	8.5	8.9	5.3
Between the mounds	0— 2	36	46	18	4.82	1.00	3.6	1.3	1.4	1.4
	2— 25	29	55	16	4.01	0.98	10.6	4.9	2.3	2.4
	25— 50	35	49	16	4.15	0.96	10.1	6.2	5.4	3.7
	50— 75	37	38	25	4.55	1.46	8.7	10.5	8.6	5.5
	75—100	48	26	26	5.01	1.84	12.1	10.0	9.5	7.7

The moisture equivalent values decrease steadily as the depth increases in the mound body and below it. More or less homogeneous values are observed at different depths in the soil between the mounds.

d) *Soil moisture content*

Examination of Table 1 reveals the following:

(1) The soil moisture content decreases at the various layers by the advent of the dry season, reaching low levels in September, (2) considering the hygroscopic water non-available, the mound body contains available moisture at depth of 20—50 cm almost all the year round, at a depth of 5—20 cm during three seasons and at a depth of 0—5 cm during the rainy season only, (3) there is ample supply of water to the plant at deep layers below the mound body during the whole year, (4) at deep layers, the soil moisture content is higher in soils between the mounds than below the mound body by the end of the dry season, a phenomenon attributed to rapid depletion of water below the mound body by absorbing roots.

e) *Total soluble salts*

It is remarkable that the plant studied grows in soils varying widely in their salt content. However, the plant is prosperous and dominates the vegetation in less-saline habitats. A glance at Tables 2 and 3 reveals that the amount of the total soluble salts in the mound body ranges from 13.3 to 25.5% in the highly saline habitat, and from 1.1 to 3.5% in the less-saline habitat. This shows the wide range of salinity under which the plant grows. As regards the vertical distribution of salts, they are higher in the mound body than between the mounds in both habitats. Below the mound, in the less saline habitat, the salts increase from 0.8% at a depth of 0—25 to 2.2% at a depth of 75—100 cm. Between the mounds, the salt content is lower than in the mound body.

f) *Anions*

Chlorides are the dominant anions in the two habitats and their amount decreases by the increasing depth in the mound body, ranging from 468 to 241 mg/100 g in the less-saline habitat and from 418 to 7896 mg/100 g in the highly saline habitat (Tables 2 and 3). Below the mounds, the chloride content is lower than in the mound body, but slightly higher than between the mounds in the less-saline habitat.

Sulphates range from 128 to 336 mg/100 gm in the less-saline habitat and from 640 to 2760 mg/100 gm in the highly-saline habitat. They exhibit higher values in the mound body than below it in the latter habitat.

Table 2

Soil analysis of samples collected from successive depths in the mound body, below it and between the mounds in the less-saline habitat

Site	Depth (cm)	pH	Total sol. salt %	Anions (mg/100 gm)			Cations (mg/100 gm)				Total carbonates (%)	Organic carbon (%)
				Cl^-	SO_4^{--}	HCO_3^-	Na^+	K^+	Ca^{++}	Mg^{++}		
Mound body	0— 5	7.7	2.6	468	134	100	300	120	1.5	1.3	7.3	0.42
	5— 20	7.6	1.1	335	265	107	315	124	1.2	0.3	7.1	0.52
	20— 50	7.7	3.5	241	128	153	235	125	1.4	0.2	6.3	0.54
Below the mound	0— 25	7.5	0.8	228	336	122	151	87	1.4	0.3	8.0	0.40
	25— 50	7.4	1.9	208	163	97	118	82	1.2	0.8	8.3	0.41
	50— 75	7.4	1.3	345	130	76	290	125	1.1	0.4	7.2	0.15
	75—100	7.3	2.2	304	208	61	375	116	1.4	0.7	7.8	0.28
Between the mounds	0— 25	7.2	0.4	133	143	96	98	48	0.9	0.2	7.5	0.25
	25— 50	7.2	0.6	133	200	96	95	44	1.1	0.2	7.8	0.17
	50— 75	7.1	3.0	359	196	46	250	129	2.1	0.9	7.6	0.19
	75—100	7.1	2.2	382	223	61	350	118	3.8	1.9	7.8	0.29

Table 3

Soil analysis of samples collected from successive depths in the mound body, below it and between the mounds in the saline habitat

Site	Depth (cm)	pH	Total sol. salt %	Anions (mg/100 gm)			Cations (mg/100 gm)				Total carbonates (%)	Organic carbon (%)
				Cl^-	SO_4^{--}	HCO_3^-	Na^+	K^+	Ca^{++}	Mg^{++}		
Mound body	0— 5	8.1	25.5	7896	2360	458	663	252	32.0	40.5	2.7	0.20
	5— 20	8.1	13.3	4189	2760	458	313	119	33.3	39.3	2.4	0.40
Below the mound	0— 25	8.2	3.9	950	1880	305	50	11	12.5	15.3	1.7	0.04
	25— 50	8.0	3.9	1065	680	305	69	16	10.0	3.5	2.4	0.05
	50— 75	8.1	3.3	898	640	305	75	16	6.5	3.0	2.6	0.05
	75—100	1.2	5.5	1775	720	305	106	39	9.5	6.5	3.0	0.20
Between the mounds	0— 25	8.0	6.5	2059	2960	305	94	29	26.8	25.3	8.4	0.30
	25— 50	7.5	4.0	959	2040	458	80	14	18.0	7.8	8.3	0.04
	50— 75	7.0	2.4	746	760	610	50	14	6.0	0.5	8.3	0.06
	75—100	7.5	4.6	1180	2160	305	69	15	17.5	5.5	9.2	0.12

The bicarbonate content is higher in the highly-saline habitat (305 to 458 mg/100 g) than in the less-saline habitat (61 to 153 mg/100 g). Bicarbonates are higher in the mound body than below the mounds in the two habitats. Between the mounds, the bicarbonate content is very low in the less-saline habitat, but with considerable values in the saline habitat (305—610 mg/100 g).

g) *Cations*

Sodium is the dominant cation in all samples studied (Tables 2 and 3). It has higher values in the mound body than below it or between the mounds. In the mounds, its amount ranges from 235 to 315 mg/100 g in the less-saline habitat and from 313 to 663 mg/100 g in the highly-saline habitat. It is remarkable that the sodium content below and between the mounds is higher in the less-saline than the highly saline habitat. Potassium content is lower than that of sodium, but it shows the same trend as sodium in the various sites. The calcium ion is very low in the less-saline habitat compared to that in the highly saline one, ranging from 0.9 to 3.8 mg/100 g in the former habitat and from 6 to 33.5 mg/100 g in the latter. Calcium exhibits a more or less homogeneous distribution in the mound body and below it in the less-saline habitat, but it is higher in the mound body than below it in the highly-saline habitat. Magnesium content is very low in the less-saline habitat (0.2—1.9 mg/100 g), but it shows high values in the highly-saline habitat (0.5—40.5 mg/100 g). It exhibits nearly the same trend as calcium.

h) *Total carbonates*

The carbonate content calculated as calcium carbonate in the mound body and below it is much higher in the less-saline habitat (6.3—8.3%) than in the highly-saline habitat (1.7—3%). The vertical distribution of the total carbonates is almost homogeneous in both cases. Between the mounds, the carbonates are higher in the highly-saline habitat than in the less-saline one.

i) *Organic carbon*

The values of the organic carbon content are higher in the less-saline (0.15—0.52%) than in the highly-saline habitat (0.04—0.4%). In both cases, the highest organic carbon content is observed in the mound body.

j) *pH value*

In general, the pH values in all sites are on the alkaline side. Higher pH values are observed in the highly-saline habitat than in the less-saline habitat.

Root studies

Root systems of *Limoniastrum* were studied at the successive stages of mound formation in the less-saline habitat (Fig. 3). The young individual, 10 cm high, grows on the level ground without any sand accumulation. The root of this plants extends about 60 cm deep into the soil, with only a few fine superficial and deep laterals extending 20 cm on both sides. The growth of the plant goes hand in hand with the accumulation of soil material around the body of the plant. More lateral long roots are produced with a lateral extension of 1 m. A small mound, 5 cm high, is formed at this stage. Further growth of the plant is accompanied by an increase of the mound size and the burial of old shoots and the formation of adventitious roots. More lateral roots with more lateral extension are formed at this stage. Continuous growth of the plant and subsequent sand accumulation and increase of the mound body are accompanied by obvious changes in the root system. In the mature mound, 50 cm high and 120 cm in diameter, the main root system becomes thick and it branches into numerous long laterals extending horizontally (140 cm) and vertically (80 cm). Numerous adventitious roots are produced in the mound body. Two types of these roots are produced: fine tufts of short roots and long fibrous dense roots. The fine short roots, produced in tufts, are "ephemeral roots" produced during the wet season and which vanish and lose their activity by the advent of summer. In the wet season, the soil in the mound body has a relatively high moisture content that stimulates the formation of these roots. This type of roots does not extend below the mound body. The long adventitious roots are produced from the buried stems and they extend in all directions. The root system of the mature plant extends laterally on both sides for a distance of 180 cm and vertically for 80 cm below the mound body. The huge numbers of the adventitious roots contribute, to a great extent, to the total water intake of the plant. It is to be noted that at all stages of growth the root/shoot ratio is high and it increases by the aging of the plant.

The study of the root habit of a species growing under different conditions is of great importance as an indicator of plant-water and soil relationships (Batanouny and Zaki, 1969). As is clear from the foregoing results, the plant grows in highly saline habitats with a shallow saline water-table (60 cm deep). Fig. 4 shows the root system of *Limoniastrum* growing in this habitat. The root system of this plant is widely different from that of a plant growing under less-saline conditions. The stunted plant growth with a small number of shoots forms a low mound, less than 20 cm high. The root system is represented by a thick main root penetrating the soil obliquely and producing a limited number of laterals. The maximum depth is 50 cm, but roots extend horizontally for a distance of 2 m. It is evident that the presence of a high ground-
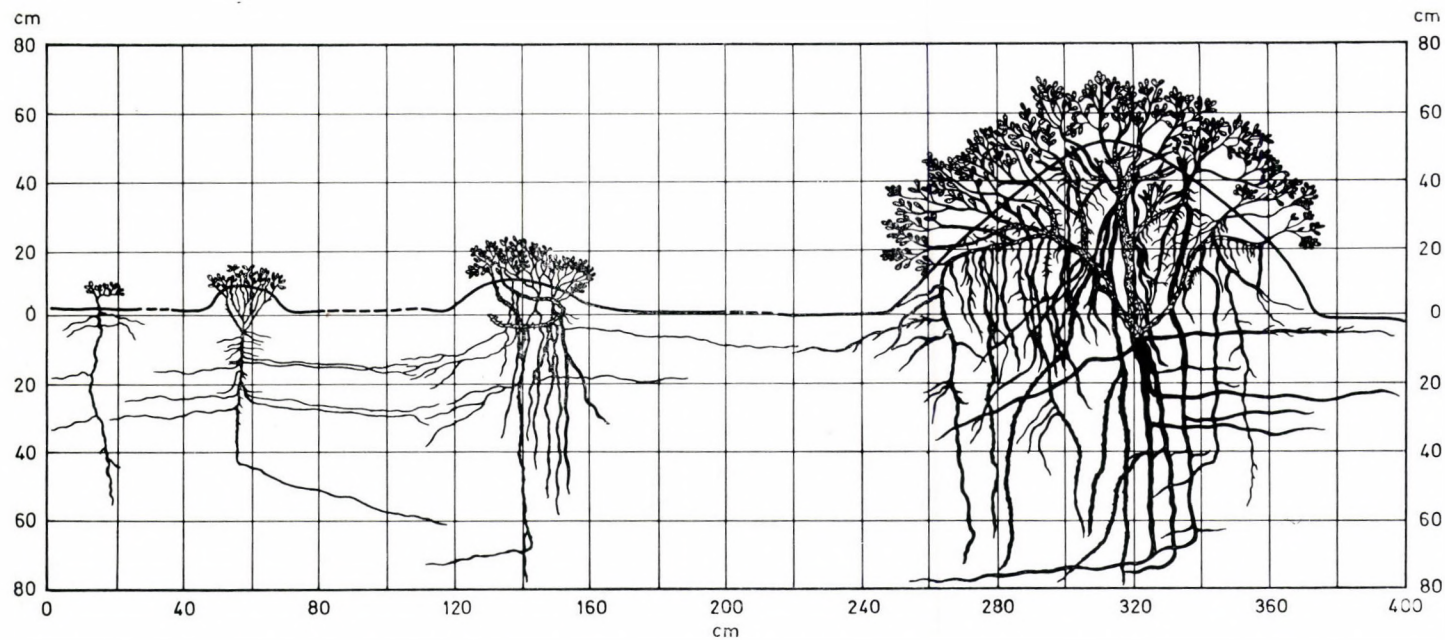
Fig. 3. The root systems of *Limoniastrum monopetalum* plants at the successive stages of mound formation by the plant
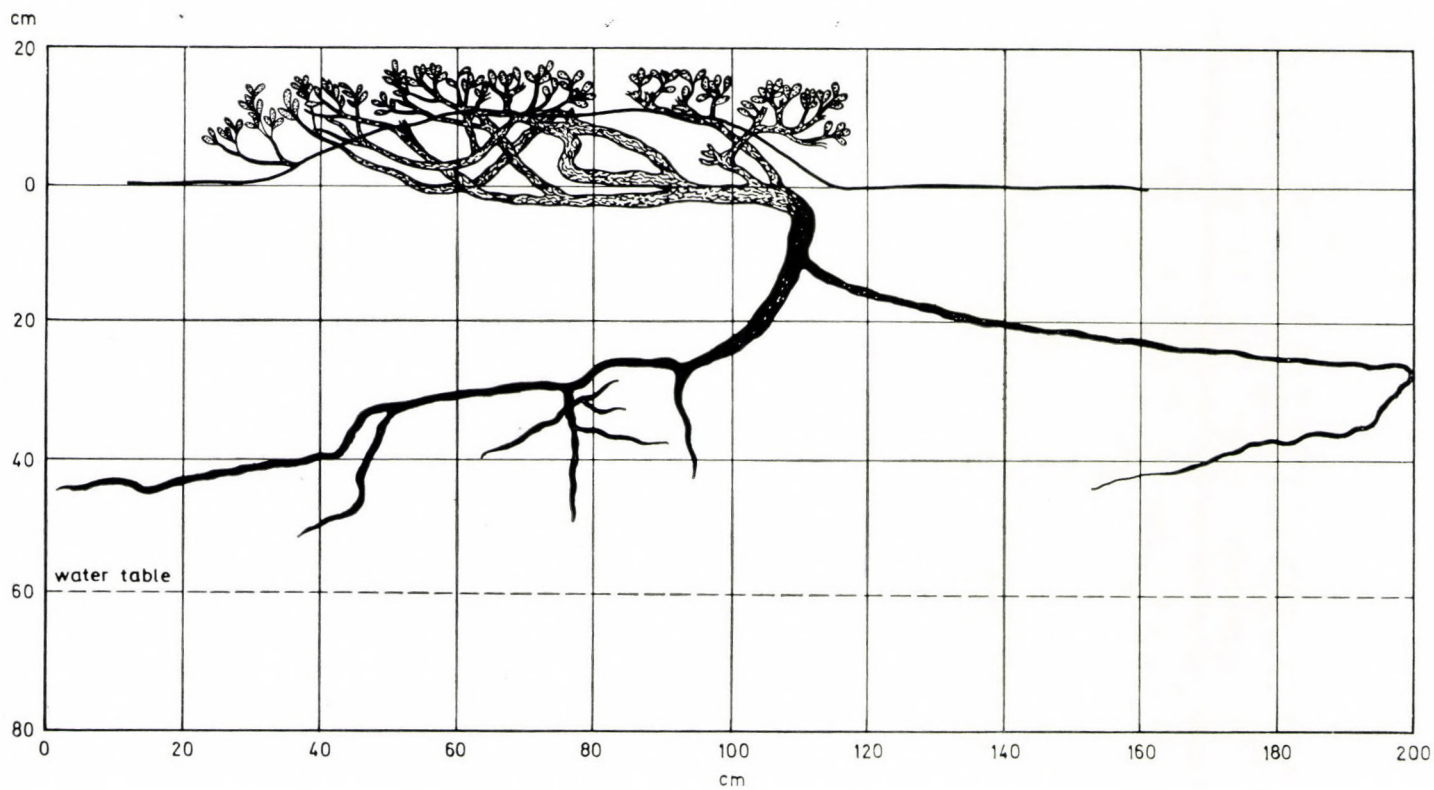
Fig. 4. The root system of ***Limoniastrum monopetalum*** growing in the saline habitat

water level hinders the growth of the root system (KOLESNIKOV, 1971 and ZAYED, 1973). High salinity causes an osmotic stress which reduces the water availability and thus hinders the production of adventitious roots.

Secreting glands in Limoniastrum

Limoniastrum monopetalum has two types of glands differing in structure, distribution and function. These glands are the chalk (salt) glands and the mucilage glands.

Chalk (salt) glands

Salt glands have been described by many investigators in the nineteenth century (DE BARY, 1977; VOLKENS, 1884; MARLOTH, 1887). These studies were followed by SCHTSCHERBACK (1910), RUHLAND (1915), DE FRAINE (1916), and recently by ARISZ et al. (1955), ZIEGLER and LÜTTGE (1966) and LÜTTGE (1971).

The salt or chalk glands in *Limoniastrum monopetalum* are present on both surfaces of the leaves (Fig. 5) as well as on the young stems (Fig. 6). The average number of glands is 2315/cm^2 on the lower surface of the leaf and 1955/cm^2 on the upper surface. In the plant growing under highly-saline conditions, the number of glands is 2406/cm^2 on the lower surface and 1979/cm^2 on the upper surface. It is remarkable that the leaf area varies widely in different habitats, being 108 mm^2 in the highly-saline habitat and 196 mm^2 in the less-saline habitat. In plants transplanted to the garden and under low salinity and adequate moisture supply, the leaf area is 205 mm^2, having 1759 gland/cm^2 on the lower surface and 1373 gland/cm^2 on the upper surface. It is to be noted that the number of glands is much fewer than that of the stomata.

The chalk glands in *Limoniastrum* are depressed below the level of the epidermal surface (Figs 5, 6 and 8). This facilitates the retention of the excreted mass of lime, which disappear by the addition of HCl to the leaf. VOLKENS (1884) claimed that the physiological significance of these chalky excretions is the protection against excessive transpiration.

The structure of these glands was incorrectly described by VOLKENS (1884) as consisting of 8 cells surrounded by 4 "Nebenzellen". BATANOUNY (1973) found that the gland is formed of 12 cells surrounded by 4 subsidiary "Nebenzellen". The twelve secretory cells arranged in groups of four cells each, separated by thin walls at right angles to each other and perpendicular to the surface (Fig. 7). The four subsidiary cells surround the secretory cells. A pit is situated on the top of the gland and is surrounded by a transversal opening on the leaf surface. The twelve glandular cells have extremely thin walls, except, to a slight extent, the walls adjacent to the base of the gland.
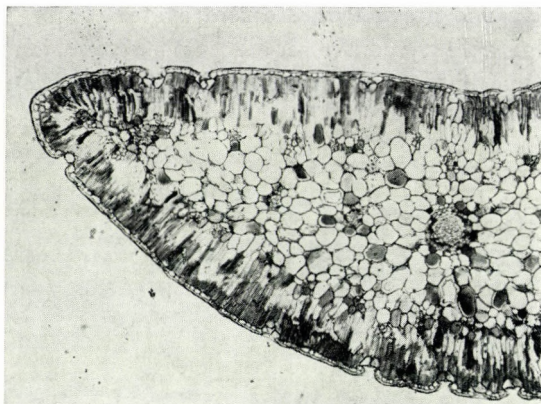
Fig. 5. T. S. in *Limoniastrum monopetalum* leaf showing the depressed chalk glands on both surfaces
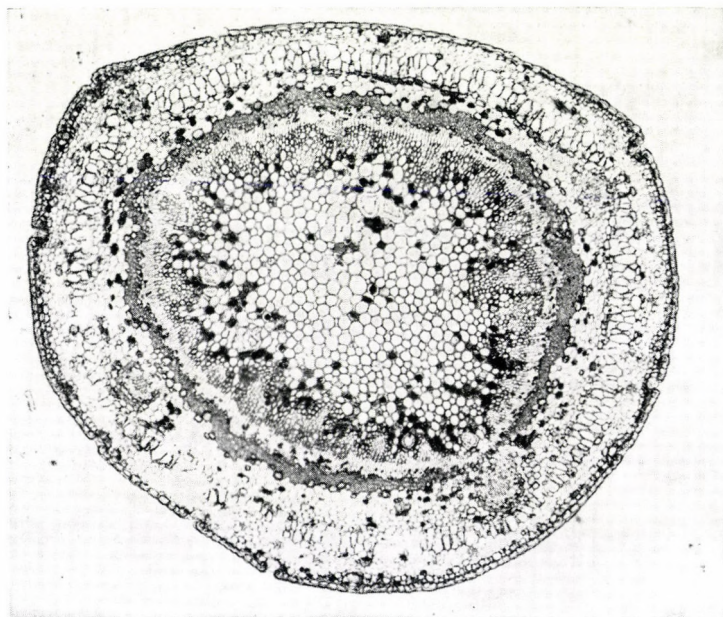
Fig. 6. T. S. in *Limoniastrum monopetalum* stem showing the depressed chalk glands on the epidermis

The glandular cells lack central vacuoles and have a granular cytoplasm and large nuclei. The outer walls of the subsidiary cells are strongly cutinized. Also, the upper sides of the gland and the neighbouring epidermal cells are covered by a thick cuticle. A rigid structure enclosed by cutinized walls is formed below the leaf epidermis in which the gland is firmly inserted (Fig. 8).
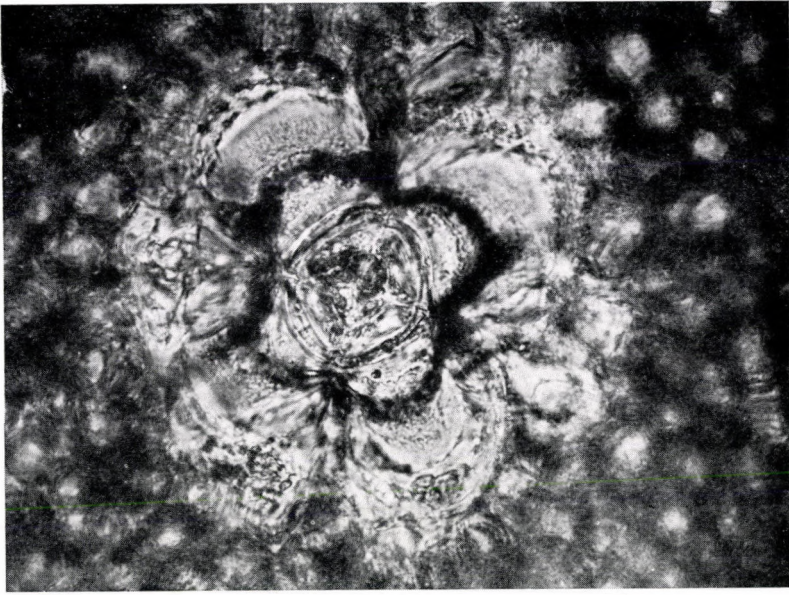
Fig. 7. Surface view of the chalk gland of *Limoniastrum monopetalum.* Note the arrangement of the secretory cells and the transversal opening of the gland

Fig. 8. A part of a T.S. in *Limoniastrum monopetalum* leaf showing the depressed glands below the epidermal level. Note the cutinization around the gland

Mucilage glands

The mucilage glands in different *Limonium* spp. were studied by De Fraine (1916). In *Limoniastrum*, these glands occur at the base of the leaf sheath, on its upper surface in contact with the stem. In the other lower (outer) surface, there are chalk glands. The mucilage glands occur abundantly

Fig. 9. T. S. in the basal part of the leaf sheath of *Limoniastrum monopetalum* showing the mucilage glands raised above the upper epidermis
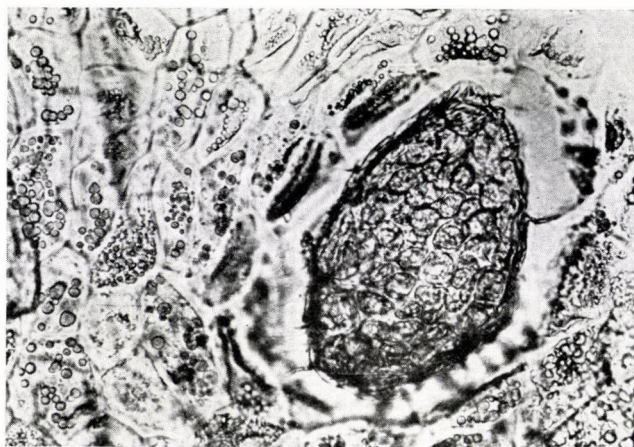
Fig. 10. Surface view of the mucilage gland of *Limoniastrum monopetalum*

at the extreme base of the leaf sheath and decrease upwards, towards the leaf, till they are replaced by chalk glands.

The mucilage glands are raised above the epidermis, on a base consisting of a few stout cells (Fig. 9). The secretory cells vary in number and they are prismatic, columnar or concial in shape. They have very thin walls and are very rich in cytoplasm. The glandular cells are enclosed by large non-secreting subsidiary cells. The entire gland is encased in a cutinized layer. The mucilage gland has a circular or oval outline in the superior view (Fig. 10).

Discussion

Limoniastrum monopetalum is a salt-secreting halophyte. The area in which the plant grows has an attenuated subdesertic climate. The plant has a limited geographical distribution, being rectricted to particular areas in the Western Mediterranean coastal zone of Egypt. Being endowed with special characteristics, the plant is able to form mounds. The formation of these mounds has many ecological consequences. The soil properties, both physical and chemical, are widely different in the mound body, below it and between the mounds. Such variation is reflected on the plant-water and soil relationship. Accumulation of soil material around the plant body stimulates the production of adventitious roots which participate to a great measure in water absorption by the plant. In the rainy season, the moisture in the mound body stimulates the production of very fine tufts of short adventitious roots. These roots are of ephemeral nature, i.e. they vanish by the advent of summer. The long fibrous adventitous roots are numerous and permanent, and they represent the main absorbing system of the plant. They extend in different directions for long distances in and below the mound body. Salinity hinders the production of adventitious roots, hence plants growing in very saline habitats produce no adventitious roots.

The plant, with a potential ability to form mounds, causes the rise of the ground level; consequently, the ground water level becomes deeper. Coalescence of the mounds results in elevation of the ground level above the common level of the surrounding marshes. The plant occupies elevated belts bordering the salt marshes. This leads to a decrease of salinity, and usually the land occupied by *Limoniastrum* in the Mediterranean coastal-zone is cultivated by barley, indicating the important role of this plant in reclaiming the soil. The newly trapped soil material among the intricate branches of this plant is fine in texture and easily penetrable. Moreover, the impregnated dead vegetative parts in the mound body enrich the soil with organic matter.

The plant has chalk (salt) and mucilage glands. The chalk glands are present on the leaves and on the young stems, while the mucilage glands occur

at the base of the leaf sheath on the upper epidermis. Both types of gland differ as regards distribution on the plant body, structure and function.

The salt-secretion from the chalk glands appears on the leaf surface as whitish tubercles, which disappear by the addition of drops of hydrochloric acid. Through the activity of these glands, the plant liberates excess salts in the plant body. In a future study, the secretion of these glands will be investigated under laboratory conditions. The presence of these secretions on the surface of the transpiring organs may be a mechanism by which the plant reduces it water expenditure. The next paper of this series will deal with the water relations of this plant. It is probably that the mucilage secreted by the mucilage glands play a role in the water relations of the plant studied. The secreted mucilage absorbs the atmospheric humidity and the plant may benefit from this moisture.

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TETRAZYGIOPSIS, GÉNERO NUEVO DE LAS ANTILLAS Y EL GÉNERO TETRAZYGIA L. C. RICH. (MELASTOMATACEAE) EN CUBA

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The present study contains a taxonomic revision of the Cuban taxa of the genus *Tetrazygia* L. C. Rich. with the descriptions of 3 species, 2 varieties and 3 combinations new to science and a new analytical key. This revision led to recognize a new Antillan genus differing from *Tetrazygia* in the structure of the calyx. The new genus is named *Tetrazygiopsis* and includes 2 sections and 8 species.

Durantela realización de la revisión taxonómica de las espécies cubanas del género *Tetrazygia* L. C. Rich. me llamó el atención, que algunas espécies de este género tenian una estructura del cáliz diferente de la que está descrita como caracter genérico. Particularmente en las espécies *Tetrazygia brachycentra* (Griseb.) Triana, *T. laxiflora* Naud. y *T. ekmanii* Urb. observaba, que el cáliz tiene lóbulos exteriores bien desarrollados, por lo comun notablemente más largos que los interiores. Esta caracteristica no es própria del género *Tetrazygia* ni del *Miconia*. Después de haber revisado todas las espécies antillanas del género *Tetrazygia*, encontré, que 8 de estas tienen la misma caracteristica ajena al género *Tetrazygia*. Merece mencionar, que esta caracteristica ya había impresinonado a muchos de los autores del siglo pasado, porque la mayoria de estas 8 espécies eran descritas bajo otros géneros (*Graffenrieda*, *Calycogonium* y *Pachyanthus*), para los son caracteristicos los lóbulos exteriores del cáliz bien desarrollados. Basandome en una revisión comparativa y cuidadosa llegué a la conclusión, que las espécies listadas mas abajo, no pueden pertenecer al género *Tetrazygia*, sino para ellas hay que crear un género nuevo, 10 que queremos denominar *Tetrazygiopsis*, y que es de considerar un género endémico de las Antillas.

El género se divide en dos secciones: La sección *Tetrazygiopsis* se distigue por sus flores 4-meras y ovarios 3-(4)-loculares, mientras la sección *Pachyanthopsis* se reconoce por sus flores 5-meras y ovarios 5-loculares. A la sección *Tetrazygiopsis* pertenecen 6 espécies, de las 3 son endémicas en Cuba, 1 en Jamaica, 1 en Puerto Rico, y una tiene mayor distribución en las Antillas Mayores y Menores. A la sección *Pachyanthopsis* pertenecen 2 espécies; ambas son endémicas de Española.

La descripción y la clave analitica del género son las siguientes:

Tetrazygiopsis gen. n.

Frutices vel arbores humiles Antillani, foliis 3—5-nervis petiolatis vel sessilibus, plerumque stellato-puberulis vel lepidotis, rariter glabris, inflorescentiis terminalibus paniculatis, plerumque multifloris, tubo calycino supra ovarium elongato et producto, breviter lobulato vel truncato, lobis dorso appendices subulatos vel filiformes, lobos ipsos plerumque bene superantes gerentibus, petalis plerumque 4, rariter 5, ob ovatis et obtusis, staminibus 8—10 aequalibus vel inaequimagnis, antheris linearibus vel oblongo-lanceolatis, apice uniporis, connectivo exappendiculato, ovario 3—5-loculari, calyce semiconnato, baccis 3—5-locularibus, carnosis, limbo calycis coronatis insignes.

A genere proximo, *Tetrazygia* L. C. Richard lobis exterioribus bene evolutis clare differt, et per hanc rationem charactere dicto a *Tetrazygia* recte separare posse persuasus sum. A genere *Pachyanthus* A. Richard calycibus ampulliformibus, supra ovarium elongatis et productis, inflorescentiis paniculatis, plerumque multifloris, floribus 4—5-meris, ovario plerumque 3—4-loculari sine dubio bene discrepat.

Typus generis: *Tetrazygiopsis brachycentra* (Griseb.) Borhidi

1 a Flores 4-meri; ovarium 3—(4)-loculare; folia membranacea vel chartacea (sect. *Tetrazygiopsis*) **2**

b Flores 5-meri; ovarium 5-loculare, folia coriacea (sect. *Pachyanthopsis*) **.**

2 a Folia subtus glabra vel glabrescentia **3**

b Folia subtus hirsuta vel stellato-tomentosa **4**

3 a Folia subtus glabra, fructus oblongus (End.: Cuba: Cam., Or.) .... 1. **T. brachycentra**

b Folia subtus ad nervos sparse stellato-puberula; fructus globosus (End.: Cuba: Or.: Sierra Maestra) .... 2. **T. ekmanii**

4 a Caulis, inflorescentia et folia subtus strigilloso-hispida (End.: Jamaica) .... 3. **T. hispida**

b Planta non hispida, folia subtus dense stellato-tomentosa **5**

5 a Folia sessilia, basi cordata, margine crenata (Hispaniola, Porto Rico, Antillae Minores) .... 4. **T. crotonifolia**

b Folia longe petiolata, basi obtusa vel rotundata, margine integra (End.: Cuba: PR., LV., Or.) .... 5. **T. laxiflora**

6 a Fruticulus 30—40 cm altus, folia, nervis transversalibus subrectangularibus, subtus ferrugineo-tomentosa (End.: Hispaniola) .... 6. **T. tuerckheimii**

b Frutex 1—1.5 m altus, folia nervis transversalibus acutangularibus, subtus flavo-tomentosa, baccae edibiles, usque ad 2 cm longae (End.: Hispaniola) .... 7. **T. urbaniana**

Obs.: Species nondum satis cognita: **T. biflora** e Porto Rico verisimiliter huc pertinet.

I. Sectio Tetrazygiopsis

Foliis membranaceis vel chartaceis, floribus 4-meris, ovario 3—(4)-locularibus.

1. Tetrazygiopsis brachycentra (Griseb.) Borhidi c. n.
Basionymon: *Graffenrieda brachycentra* Griseb. Plantae Wrightianae, pars I. Mém. Amer. Acad. Sci. Nov. Ser. **8.** 1860. p. 186. Typus: WRIGHT 191!
Synonyma: *Tetrazygia brachycentra* Triana in Trans. Linn. Soc. **28.** 1. 1871. — *Miconia brachycentra* Maza. Cat. de las Periant. Cuban. Anal. Soc. Esp. de Hist. Nat. **19.** 1890. p. 67.
2. Tetrazygiopsis ekmanii (Urb.) Borhidi c. n.
Basionymon: *Tetrazygia ekmanii* Urban in Fedde's Repert. **22.** 1926. p. 222. Typus: EKMAN 14 862!
3. Tetrazygiopsis hispida (Sw.) Borhidi c. n.
Basionymon: *Melastoma hispida* Swartz Prodr. 1788. p. 72.
Synonymon: *Tetrazygia hispida* Macfadyen Jam. II. 1850. p. 58.
4. Tetrazygiopsis crotonifolia (Desr.) Borhidi c. n.
Basionymon: *Melastoma crotonifolia* Desr. in Lamarck Encycl. **4.** 1797. p. 43.
Synonymon: *Tetrazygia crotonifolia* DC. Prodr. **3.** 1828. p. 172.
5. Tetrazygiopsis laxiflora (Naud.) Borhidi c. n.
Basionymon: *Tetrazygia laxiflora* Naudin in Annal. Sci. Nat. Sér. III. **15.** 1851. p. 343.
Synonyma: *Tetrazygia elaeagnoides* Griseb. in Cat. Plant. Cub. 1866. p. 98. non DC. — *Miconia rangeliana* Wright in Griseb. l.c. p. 99. Typus: WRIGHT 2512! Cuba: Pinar del Rio: Rangel.
6. Tetrazygiopsis biflora (Cogn.) Borhidi c. n.
Basionymon: *Calycogonium biflorum* Cogniaux in Jahrb. Bot. Gart. u. Mus. Berlin **4.** 1886. p. 276.
Synonyma: *Tetrazygia krugii* Cogniaux in DC. Monogr. **7.** 1891. p. 719. — *Tetrazygia biflora* Urban in Fedde's Repert. **17.** 1921. p. 405.

II. Sectio Pachyanthopsis Borhidi sect. n.

Frutices foliis coriaceis, floribus 5-meris, ovario 5-loculari.

7. Tetrazygiopsis tuerckheimii (Cogn.) Borhidi c. n.
Basionymon: *Pachyanthus tuerckheimii* Cogniaux in Urban Symb. Ant. **7.** 1912. p. 314. Typus: TÜRCKHEIM 3148.
Synonyma: *Tetrazygia humilis* Urb. et Ekm. in Ark. f. Botanik **22 A** No. 17. 1929. p. 31. — *Tetrazygia tuerckheimii* Ekman ex Urb. in Ark. f. Botanik **23 A** No. 11. 1931. p. 16.
8. Tetrazygiopsis urbaniana (Cogn.) Borhidi c. n.
Basionymon: *Pachyanthus urbanianus* Cogniaux in Urban Symb. Ant. **7.** 1912. p. 313. Typus: TÜRCKHEIM 3196.
Synonyma: *Tetrazygia macrocarpa* Urb. et Ekm. in Ark. f. Botanik **22 A** No. 17. 1929. p. 30. — *Tetrazygia urbaniana* Croizat in Moscoso Cat. Flor. Doming. 1943. p. 457.

El género Tetrazygia L. C. Rich. en Cuba

Arboles o arbustos escamosos; hojas 3—5-nervias; flores pequeñas, 4—6-meras en panojas o corimbos terminales, blancas o rosadas. El tubo del cáliz estrechado a contraído arriba del ovario; el limbo 4—6-lobulado o subtruncado, lóbulos exteriores del cáliz inconspicuos o ausentes. Pétalos 4—6, obovados, obtusos. Estambres 2 veces tantos como los pétalos, iguales o subiguales; filamentos subulados, anteras lineales, poro 1, apical, conectivo sin apéndices. Ovario 2—6-locular, semi-adherente; estilo encorvado, filiforme,

estigma puntiforme. Baya 2—6-locular, carnosa, coronada por el limbo del cáliz. 15—20 espécies de las Antillas y Guayana.

Clave analítica para las espécies cubanas:

1 a Flores 4-meras, ovario 2—(3)-locular **2**
b Flores 5—(6)-meras, ovario 3—6-locular **3**
2 a Hojas redondeadas en el ápice . . . . 1. **T. elegans** Urb.
aa Hojas de 3.5—6 cm., cubiertas por escamas amarillas, fimbriadas 1/a. **var. elegans**
bb Hojas de 2—4 cm. de largo, cubiertas por escamas de margen entero . . . . 1/b. **var. cacuminis** Borhidi
b Hojas atenuadas y agudas en el ápice (End.: Or.: Sierra Maestra). . . 2. **T. urceolata** (Urb.) Borhidi
3 a Indumento ferrugíneo-estrellado, ovario 5—6-locular (End.: LV: Sierra de Escambray) . . . . 3. **T. aurea** Howard et Briggs
b Indumento blanco-grisaceo a parduzco, ovario 3—4-locular **4**
4 a Hojas fuertemente reticulado-venosas y estrellado tomentosas en el envés (Cuba: PR., IP., Guayana) 4. **T. delicatula** (A. Rich.) Borhidi
b Hojas no reticulado-venosas, el envés escamoso **5**
5 a Lóbulos del cáliz triangulares y agudos de 2—3 mm. de largo, hojas nítidas, y reticuladas en el haz, el envés escamoso de escamas peltadas multiradiadas (End.: Or.: Sierra del Cristal) . . . . 5. **T. cristalensis** Borhidi
b Lóbulos del cáliz redondeados a truncados hasta de 1.5 mm. de largo; hojas mayormente mates y no reticuladas en el haz **6**
6 a Hojas de 3.5—6 cm. de largo, inflorescencias de 2—5 cm. **7**
b Hojas de 6—14 cm. de largo, inflorescencias de 6—20 cm. **8**
7 a Hojas densamente albo-escamosas en el envés, a veces callosas o barbudas en las axilas de los nervios (End.: Mogotes de PR.) . . . . 6. **T. lanceolata** Urb.
aa Hojas largamente acuminadas, baya oblonga de 7—8 mm. de largo (End.: Pan de Guajaibón) . . . . . . 6/a. **ssp. lanceolata**
bb Hojas atenuadas en el ápice, baya globosa de 4—6 mm. de largo (End.: Sierra de la Güira) . . . . 6/b. **ssp. minor** (Urb.) Borhidi
b Hojas glabrescentes, sin callos o grupo de pelos en las axilas del envés (End.: Or.: Pico Turquino) . . . . 7. **T. acunae** Borhidi
8 a Hojas ferrugineo- a pardo-escamosas en el envés **9**
b Hojas blancuzcas a plateado-escamosas en el envés **10**
9 a Hojas coriáceas de 6—9 cm., no hirsutas en las axilas de los nervios del envés (End.: PR.: Cajalbana) . . . . 8. **T. coriacea** Urb.
b Hojas cartáceas de 8—14 cm., nervios laterales hirsutos a barbudos en las axilas del envés (End.: Or.: Moa) . . . . 9. **T. barbata** Borhidi

10 a Hojas de 6—9 cm., nervios primarios hundidos en el envés, inflorescencia pauciflora de 6—8 cm. (End.: PR.: Sierra del Rosario) ....
10. **T. impressa** Urb.

b Hojas de 8—14 cm., nervios primarios poco hundidos en el haz, apenas prominulos en el envés; inflorescencia multiflora de 10—20 cm. de largo (Cuba, Española, Jamaica, Bahamas y Florida) ....
11. **T. bicolor** (Mill.) Cogn.

aa Ramitas, pecíolos e inflorescencia sin pelos largos extendidos ...
11/a. **var. bicolor**

bb Ramitas, pecíolos e inflorescencia con pelos largos extendidos...
11/b. **var. patenti-setosa** Borhidi

Tetrazygia elegans Urb. var. **cacuminis** Borhidi var. n.

A typo differt: foliis 2.5—4 cm longis, subtus lepidibus margine integris obsitis, inflorescentiis usque ad 2 cm longis, fructibus 3—3.5 mm longis.

Holotypus: BUCHER 140; Cuba: Prov. Oriente; Sierra Maestra, Mogote Peak, Pico Turquino. Leg.: C. G. BUCHER 29. febr. 1930.

Tetrazygia urceolata (Urb.) Borhidi comb. n.

Basionymon: *Miconia urceolata* Urban in Symb. Ant. 9. 1923. p. 116.

Adde ad descriptionem: limbus calycis sub anthesi et in fructu supra ovarium manifeste elongatus et productus, superne ampliatus, lobi exteriores calycis tuberculati, minuti, ovarium fructusve quasi semper 2-loculares. Sine dubio *Tetrazygia* ex affinitate *T. elegantis* Urb., a qua foliis apice attenuatis et acutis, calycibus fructibusve gibberoso-squamosis differt.

Tetrazygia delicatula (A. Rich.) Borhidi comb. n.

Basionymon: *Miconia delicatula* A. Richard in La Sagra: Historia Fis. Pol. Nat. de la Isla de Cuba X. 1845. p. 268. — Synonyma: *Tetrazygia elaeagnoides* Griseb. in Cat. Plant. Cub. 1866. p. 98.

Adde ad descriptionem: limbus calycis sub anthesi et in fructu supra ovarium manifeste elongatus et productus, superne infundibuliformiter elatus. Ovarium 3-loculare.

Tetrazygia cristalensis Borhidi sp. n.

Arbor parva. Rami hornotini tenuiter 4-angulati, lepidibus peltatis, lanceolatis vel linearibus, multiradiatis, ferrugineis vel brunnescentibus densissime obtecti. Folia 1—2 cm longe petiolata, petiolis basi 1.5—3 mm crassis, convexis, supra anguste sulcatis, dense brunneo-lepidotis suffulta, lanceolata vel oblongo-lanceolata, basi obtusa vel rotundata, antice longe acuminata, apice ipso obtusa, 7—14 cm longa et 2.5—4 cm lata, basi trinervia cum nervis 2 marginalibus, transversalibus inter sese 4—7 mm remotis, omnibus supra impressis et reticulato-anastomosantibus, subtus tenuiter sed manifeste prominulis, obsolete reticulato-venosis, supra nitida, initio sparse lepidota, mox glabra et obsolete punctata, subtus lepidibus griseis vel plerumque flavo-aeruginosis permultiradiatis densissime obtecta, domatiis nullis

suffulta, margine integra, plana, coriacea. Inflorescentiae terminales 2—3 cm longe pedunculatae, panicula anguste pyramidata, pauciflora, 4—7 cm longa, pedicellis 4—6 mm longis. Calyx fructifer 9—14 mm longus, limbo 3—4 mm longo, utrinque lepidoto; lobi 5, triangulares, acuti, 2—3.5 mm longi, dorso carinati, exappendiculati. Petala 5, obovata, 6—7 mm longa, basi breviter stipitata. Stamina 10. Ovarium 3-loculare. Fructus subglobosus non pleno maturus 8 mm longus, 6 mm in diam.

Holotypus: Cuba: Prov. Oriente; Sierra del Cristal, entre Los Mulos y Corea, alt. aprox. 630. m.s.m. Leg.: M. López Figueiras (UO 279) 27—28. aug. 1958. SV! Isotypus: SV!

Tetrazygia acunae Borhidi sp. n.

Frutex vel arbor parva. Rami hornotini 4-angulati, striati, lepidibus griseis minutis et adpressis obsiti vel glabrescentes, vetustiores teretes, striati et dense lenticellati. Folia 10—15 mm longe petiolata, lanceolata vel oblongo-lanceolata, antice longe acuminata, apice ipso acuta, basi obtusa, 3—5.5 cm longa et 0.8—1.5 cm lata, e basi trinervia, nervis supra parum impressis, subtus prominentibus, lateralibus a margine 1—2 mm remotis, transversalibus inter sese 2—4 cm distantibus, supra obsolete impressis vel inconspicuis, subtus conspicuis non prominulis nec reticulatis; lamina supra in sicco nigrescens, rugulosa, initio griseo-lepidota, mox glabra, rugulosopunctata, subtus pallidior, griseo-lepidota mox glabriuscula, margine integra, tenuiter recurva, pergamacea. Inflorescentiae 0.5—1 cm longe pedunculatae, pauciflorae, ipsae 1—2 cm longae, pedicellis 4—5 mm longis. Calys fructifer 7—9 mm longus, limbus 2—3 mm longus, lobi 5, breviter triangulares, 1—1.5 mm longi. Stamina 10. Fructus globosus 5—6 mm in diam., 3-locularis.

Holotypus: Acuña 19 452; Cuba: Prov. Oriente: Sierra Maestra, Pico Turquino. Leg.: J. Acuña jul. 1936. SV!

Obs.: Ex affinitate *T. lanceolati* Urb. et *T. minoris* Urb. (ambae ex mogotibus prov. Pinar del Rio) sed ab illis ramulis 4-angulatis, foliis nigrescentibus et subtus glabriusculis, non domatiatis, pergamaceis vel subchartaceis differt.

Tetrazygia barbata Borhidi sp. n.

Arbor parva usque ad 5—6 m alta. Rami hornotini crasse 4-angulati, lepidibus minutis, ellipticis vel lanceolatis, brunnescentibus, margine fimbriatis dense obsiti, vetustiores teretes, glabri, tenuiter striati. Folia petiolis 1—4 cm longis, basi 2—2.5 mm crassis, supra canaliculatis, lepidotis suffulta, lanceolata vel ovato-lanceolata, basi obtusa vel breviter angustata, antice longe acuminata, 6—11 cm longa et 2.5—4 cm lata, e basi trinervia cum nervis 2 marginalibus a margine 0.5—1 cm distantibus, transversalibus inter sese 3—5 mm remotis, supra tenuiter impressis, subtus bene prominentibus, lamina supra in sicco obscure viridis, minute granuloso-muricata, subtus lepidibus rotundis vel semiorbicularibus, radiatis, valde adpressis initio subdense obsita, mox glabrescens, pallide flavo-brunnea, basi inter nervos vel plerumque etiam in axillis nervorum transversalium ferrugineo-domatiata, margine integra, plana vel tenuiter recurva, chartacea. Inflorescentiae terminales 4—6 cm longe pedunculatae, ipsae 5—8 cm longae, pedicellis 1—2.5 cm longis. Calyx 6—7 mm longus, utrinque dense brunneo-lepidotus; limbus 5-lobatus, lobi semiorbiculares, 0.5—1 mm longi. Petala 5, alba, obovata, antice rotundata, excisa vel apiculata, basi 1 mm longe stipitata, 6—8 mm longa, utrinque pulverulenta. Stamina 10; filamenta 3—3.5 mm longa, sub apice paullo arcuata; antherae lineari-lanceolatae, 5—5.5 mm longae, non appendiculatae, apice 1-porae. Stylus 10—12 mm longus, apice breviter attenuatus et curvatus. Ovarium 3-loculare. Fructus ellipticus vel subglobosus, usque ad 10—12 mm longus et 6—8 mm in diam.

Holotypus: León 20 286! Cuba: Prov. Oriente; Playa de Moa. Leg.: León, Clemente et Howard 25. jul. 1941. SV!, isotypus: SV!

Specim. exam.: Pinares de Moa, León 22 506! Leg.: LEÓN, CLEMENTE, ALAIN et CRISÓGONE, 3. aug. 1945; — Moa, BUCHER, 11 442 SV!; — Yamanigüey, Taco Bay, Leg.: M. LÓPEZ FIGUEIRAS, 12. apr. 1960. UO 778 in SV! — Ibidem UO 2166 in SV!

Tetrazygia bicolor (Mill.) Cogn.
var. **patenti-setosa** Borhidi var. n.

A typo differt: ramis hornotinis, petiolis et inflorescentiis longe patenti-setulosis.

Holotypus: ACUÑA 19 461 SV! Cuba: Prov. Pinar del Rio, Cerro de Cabras. Leg.: ACUÑA et TORRES 10. oct. 1954. — Isotypus: SV!

Tetrazygia lanceolata Urb. ssp. **minor** (Urb.) Borhidi comb. n.

Basionymon: *Tetrazygia minor* Urban in Fedde's Repert. **22.** 1926. p. 224.

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THE CELLULOSE SKELETON STRUCTURE IN SOME CELL TYPES OF THE GAMETOPHYTON OF MARCHANTIA POLYMORPHA L.

I. THE ABAXIAL EPIDERMIS CELLS, THE SMOOTH RHIZOIDS, AND RHIZOIDS WITH TUBERCLED THICKENINGS OF THE CELL WALLS

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This study presents the results of light-, polarization- and scanning microscopical examinations of the abaxial epidermis cells, of the smooth rhizoids, and of those with tubercled thickenings of the cell wall structure of the gametophyton of *Marchantia polymorpha* L. Data are furnished whether in addition to the differences in their shape and size, these three types of cells show differences with respect to their sub- and light-microscopical structure.

The examinations showed that in the case of the abaxial epidermis cells and of the smooth rhizoids remarkable differences occur in the structure of the various walls of the same type of cells depending on the side from which they delimit the cell. The data on the growth and differentiation of the cell walls of the basic part of the abaxial epidermis cells and the tubercled rhizoids show that the thickening shapes, which are characteristic of the developed cell wall, appear far before the final cell size has been reached. In the anticlinal cell walls of the basic part of the abaxial epidermis cells, and of the smooth and tubercled rhizoids, a microfibril orientation perpendicular to the horizontal plane of the thallus is indicated by indirect examinations. This fact demonstrates a microfibrillation perpendicular in relation to the longitudinal growth of the cells and of the thallus. In the appendage part of both rhizoid types, the microfibrils appeared to be nearly parallel to the longitudinal axis of the appendage. The demonstration of peculiar microfibril orientations was made in the smooth and tubercled rhizoid appendages with a sinuous profile (following a helical course), and at the base of appendage of the smooth rhizoids (concentric), as well as in the tubercled thickenings of the cell wall (radial). The scanning electronmicroscopical examinations of the young smooth rhizoids confirmed the results of the indirect investigations.

Introduction

The structure of the cell wall, correlated with the growth process, the functioning of the given cell, and with the influence of the adjacent cells, all of which determine the shape of the cell, is very characteristic of the various types of the cells. Furthermore, within one single cell, the structure of the cell wall can be different depending on whether it is adjacent to a similar, or to a different type of cell, or to the external surroundings (SMITH, 1972; FRIDVALSZKY, NAGY, 1966; FRIDVALSZKY, 1967).

In the case of plants with a cellulose cell wall structure, reasonable and valuable information may be provided by the polarization microscopical exam-

ination of those structures. This celllulose cell wall is birefringent with respect both to shape and speciality. The double refraction of the shape originates from the arrangement of the microfibrils, recognized also directly by the electronmicroscope (FREY-WYSSLING, MÜHLETHALER and WYCKOFF, 1948 and PRESTON, NICOLAI, REED and MILLARD, 1948), as well as from the arrangement of the elementary fibrils running along the length of the microfibrils — periodically reaching even the crystallic level (micell) — (FREY-WYSSLING, 1954; MÜHLETHALER, 1960). The special birefringence of the cellulose cell-wall on the other hand originates from the crystal-lattice structure of the cellulose of a monoclinous system, with two optical axes, and consisting of linear chain molecules and decurrent along the elementary fibrils (SPONSLER and DORE, 1926; HERCZOG and JANCKE, 1928; MEYER and MARK, 1930; SPONSLER, 1931; ASTBURY, 1933; further, MEYER and MISCH, 1937). The direction of the greatest refractive index of the cellulose cell wall skeleton can be determined by way of polarization microscope. Thus information is provided, beyond the micells and the degree of micellation, also on the pattern of cellulose molecules (MELLORS, 1955; RUCH, 1956; FREY-WYSSLING, 1957; and ROELOFSEN, 1959). The birefringence of the cell walls can be increased by dichroic staining (RUCH, 1956; ROELOFSEN, 1959).

The great visual field depth of the scanning electronmicroscope — corresponding to about half size of the experimental object — (KIMOTO, 1972) affords the stereoscopic observation of a large part of the cell wall of a given cell. Accordingly the site of the section drawn into examination can easily and with certainty be identified. The examinations of the cell walls of whole cells can on the other hand show clearly also the means of conjointment of the individual sides. In the case of a cellulose skeleton cleared of matrix materials, the advance of the cellulose fibrils in space, and thus their possible intertwining, can with certainty be clarified by means of the scanning electronmicroscopical picture, to be traced with difficulties even in transmission electronmicroscopical pictures.

Marchantia polymorpha L. has been examined by several researchers since the last century. The cellulose structure of the types of cells occurring on the ventral surface of the lamellar thallus of the gametophyton, and the formation process of these structures, their correlation with the course of growth, the pecularities of the different functions of the entire cells and of the individual cell walls have not, however, been studied so far. Therefore this work proposed to explore the cellulose skeleton structural characteristics of the epidermal cells on the ventral surface of the dioecious gametophyton of *Marchhantia polymorpha* L., and also the characteristics of its smooth and tubercled rhizoids with regard to the correlations mentioned above.

Material and method

The gametophytons, irregarding their sex, of Marchantia polymorpha L., constituting the subject of our examinations, were collected in the green-house of the Botany Garden of the Eötvös Loránd University, Budapest. In order to make cutting more convenient, we fixed the thalluses in a mixture of formalin, glacial acetic acid, alcohol and water (Warrington, 1970), then after removing these materials in water, we processed the thalluses in 40% alcohol. For the microscopical and polarization microscopical examinations of the cell walls of different positions occurring in the abaxial epidermis, cross-sections and longitudinal sections as well as abaxial epidermis peels were prepared by hand. The position of the cells occupied in the thallus was examined on processed preparations. These, partly stained with toluidine blue and partly unstained, were coated with watered glycerine.
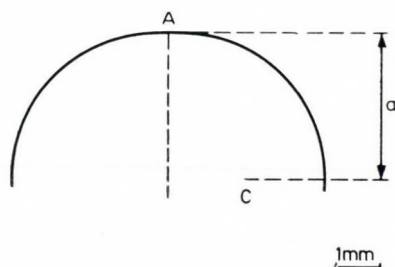
Fig. 1. Sketch of the growing apex of *Marchantia polymorpha* L. gametophyton; A = growing apex; *C* = examined cell; *a* = distance of the examined cell (*C*) from the growing apex

From the cell walls of the hand-made cross-sections and longitudinal sections, the plasma and matrix materials were removed at 90 °C by means of a trietanoamine treatment.

After washing out with water, the cellulose skeleton of the cells became suitable for polarization optical examinations (Scott and co-workers, 1956). In addition to the unstained preparations, and in order to increase the birefringence of the cell wall, part of the sections were stained with chlorine-zinc-iodine (Frey, 1927), others were stained with 1% Congo red (Wälchli, 1947; Bukovinszky, 1969). The covering of the preparations was made by means of watered glycerine which is of relatively weak refraction.

The polarization microscopic examinations were carried out by means of a Jena Zeiss-manufactured polarization microscope. For the qualitative observations, first rate red sheets were inserted.

For the scanning electronmicroscopic examinations, similarly to the polarization microscopic preparation method, fixed and purified pieces of the thallus, about 3×3 mm in size, were placed on copper lamellas of 5×5 mm size, and dried at 28 °C for 48 hours, then they were fixed to the copper lamellas by means of liquid metal-adhesive. In the further part of the preparation, the material underwent vacuum evaporation in a $2 \cdot 10^{-5}$ hgmm vacuum and was given a golden coat of about 200 Å thickness. The scanning electronmicroscopic examinations were made by means of a JSM-U-type scanning electronmicroscope.

When examining the rate of growth of the cells, their position was determined on the basis of their distance from the growth peak of the thallus measured in a longitudinal direction (Fig. 1), by means of a measuring ocular. In practice, we managed this by assuring that the position of the cell determined during the measurements remain independent of the arc-shaped curve of the peak region of the thallus. In the interests of tracing the growth rate of the cells and for the accurate determination of the cell shape, the characteristic cell wall measures of the cells were taken also by means of a measuring ocular, on the basis of the averages of 20 measurements in each case. In all cases the fully developed cell walls were examined on samples taken at an appr. 22 mm distance from the growing apex of the thallus.

Results and discussion

The abaxial epidermis of the gametophyton of *Marchantia polymorpha* L. (Fig. 2 and 7) is uniseriate. Some of its cells on the two sides of the midrib, developed into multicellular lamellae. Certain cells occurring in the areas between the lamellae formed into tubercled rhizoids with incrassate cell walls, while
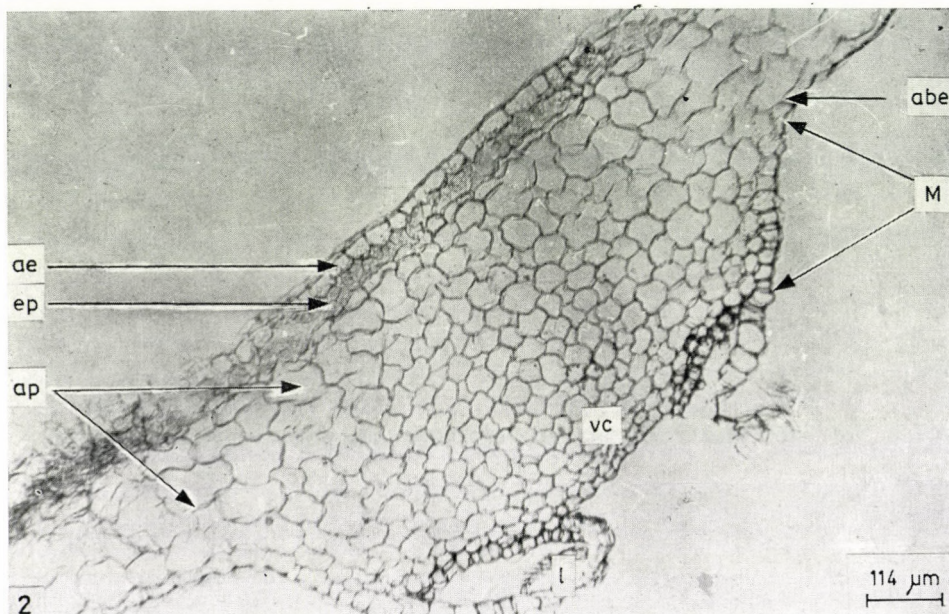
Fig. 2. Cross-sectional picture of the midrib region of a *Marchantia polymorpha* L. gametophyton; *ae* = axial epidermis; *cp* = parenchyma layer rich in chloroplasts; *ap* = layer of angulate parenchyma cells; *vc* = vascular cells; *abe* = abaxial epidermis; *l* = lamellae; *M* = = midrib-like elevation

some others into so-called smooth rhizoids without a thickening of the cell walls. The latter grow, nearly perpendicularly to the ventral surface of the thallus, towards the ground from which they absorb water. The tubercled rhizoids are parallel with the thallus (Smith, 1955).

The abaxial epidermis cells

The cellulose cell wall structure of abaxial epidermis cells with developed size and cell wall

In processed preparations, they are elongately hexagonal in a superior view. Their longer axis is nearly parallel with the midrib. The longitudinal axis of the abaxial epidermis cells covering the midrib region wholly corre-

sponds to the direction of the midrib. In the direction towards the side edges of the thallus, on the other hand, this situation turns to its very reverse in that the longitudinal axis of the abaxial epidermis cells, in relation to the midrib, turns more and more in a transversal direction.

On the basis of measures taken in the lateral near-midrib region, it can be stated that the average length of the abaxial epidermis cells lying in this region is 64 micrometer, their diameter 38 micrometer. Their smallest cell height to be seen in the cross- and longitudinal sections is 10 micrometer. The abaxial epidermis cells covering the midrib region between the ventral lamellae are smaller. Their length is 46 micrometer, their diameter 15 micrometer, their smaller height measured in their cross-section 5.5, their larger height 7 micrometer on the average. The measures taken at a distance of about five cell rows counted from the lateral margin of the thallus, that is, the measures taken near the external margin, gave an average of 79 micrometer in length, and 30 micrometer in diameter. The height data were in agreement with those of the epidermis cells in the lateral region near the midrib.

The examination of the cell wall structure was made on the abaxial epidermis cells lying in the lateral part, which is nearer the midrib. The cell walls lying in a cross-sectional plane, between crossed nicols, reveal that parallel with the height of the cell there are thickenings consisting of fine threads. These rib-like formations, which are more birefringent, are here and there free, while at other points they are only partly separated from each other. These thickenings show an additional colour in the direction identical with the great refractive index of the first-rate red sheet. Thus the orientation of the microfibrils can also be considered as identical with the direction of the thickenings. This means that the microfibrils of these cell walls are perpendicular to the direction of the longitudinal growth of the thallus. The cell walls of the abaxial epidermis cells lying in the plane of a longitudinal section show a structure similar to the former in the polarization microscopical examinations (Fig. 3).

It occurs occasionally that the joint cell wall of the abaxial epidermis cell and the great parenchyma cell above it (in a lateral thallus part!) lies in the plane of the cross-section during the cutting, affording good observation. This cell wall appears to be slightly but uniformly birefringent between crossed nicols in the polarization microscope. A complete extinction occured in agreement with the longitudinal axis of the thallus. By inserting a first-rate red sheet, it could be established that in these joint cell walls the microfibril orientation is also perpendicular to the direction of growth of the thallus. In the epidermal peel, the covering cell wall of the epidermis cells and the cell walls opposite them, which were described in the foregoing, can only be studied jointly. However, the experimental results obtained in the abaxial epidermis cells of *Marchantia polymorpha* L. (summarized in Fig. 4) support even so the

observations made earlier in examinations of other plants, namely that the cellulose structure of the cell walls can be different also within the same cell, depending on weather it is adjacent to a similar cell or to another type, thereby indicating also the functional differences of the cell walls (FRIDVALSZKY, NAGY, 1966; FRIDVALSZKY, 1967).
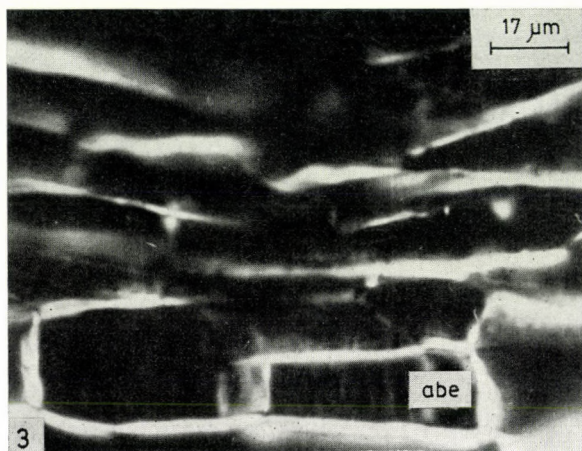
Fig. 3. Longitudinal section of mature thallus region, with the abaxial epidermis, between crossed nicols; *abe* = cell wall of an abaxial epidermis cell in the plane of a longitudinal section; its cell wall thickenings are in a diagonal position. Congo-red staining
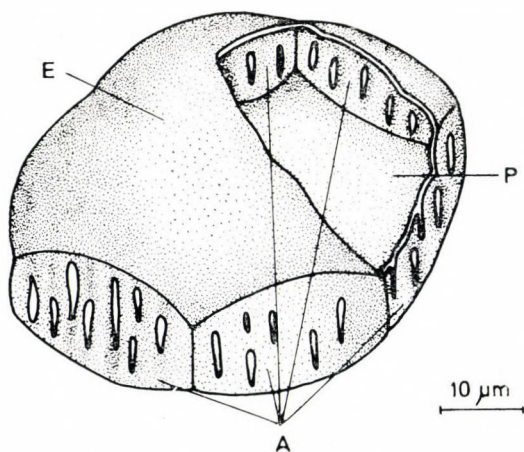
Fig. 4. Stereoscopic picture of the skeleton structure of the abaxial epidermis cell in a *Marchantia polymorpha* L. gametophyton; *E* = cell wall adjacent to the external environment; *A* = cell walls adjacent to cells of identical type; *P* = cell wall common with angulate parenchyma cells

The growth and differentiation of the cellulose structure of the abaxial epidermis cells

The length of the abaxial epidermis cells in a near-midrib lateral position, at a distance of 145 micrometer from the growing apex of the thallus, is 12 micrometer. Their length characteristic the developed state (64 micrometer) is already reached at a distance of 1500 micrometer from the growing apex. Thus their length at this 1355 micrometer phase has increased to about five times of its original size. Their height does not show any considerable change. The increase in their diameter of a value which is that of is two and a half times more than their previous diameter (it increased from 12 to 33 micrometer) at the phase mentioned before.

It was most suitable to study the differentiation of the cellulose skeleton of the growing cell at the stage of development showing the most remarkable pattern of thickening of the cell wall, namely the anticlinal cell walls displaying rib-like incrassations. The rib-like thickenings and other structural specialities (described in the previous chapter) characteristic of these cell walls in their developed state, can at the earliest be observed with the polarization microscope at 1050 micrometer from the growing apex of the thallus (see Fig. 5). The relationships between the longitudinal growth of the abaxial epidermis
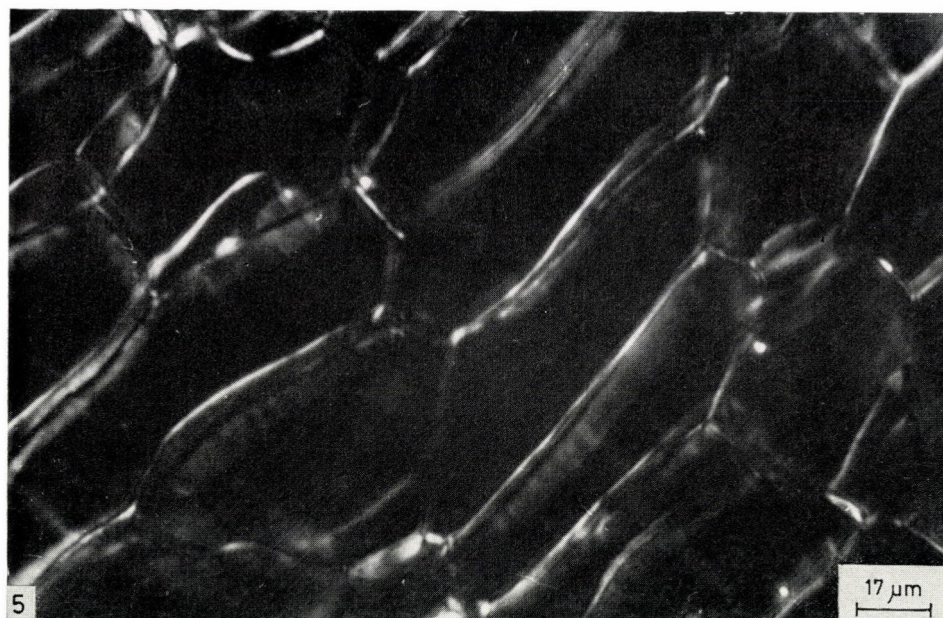
Fig. 5. Epidermal peel of a relatively young abaxial epidermis between crossed nicols. The longitudinal axis of the epidermis cells is of a diagonal position. In the cell walls lying in the plane of the preparation the more strongly birefringent wall-thickenings are already observable. Congo red staining

cells (in a lateral position) and the formation of the skeleton structure of the cell wall is shown in a graph in Fig. 6.

Although not discussed in detail, it should be noted that in the course of examinations by a polarization microscope, the anticlinal cell walls of the abaxial epidermis cells, covering the midrib region, show a cellulose structure similar to that occurring in the lateral region (Fig. 7).
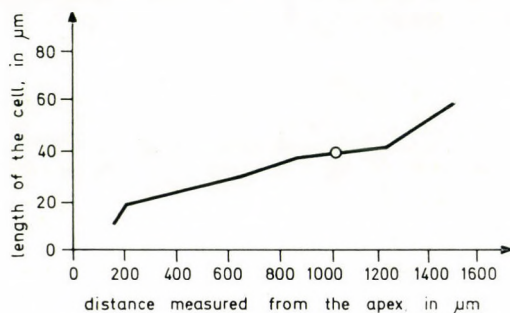
Fig. 6. Correlation between the longitudinal growth and the formation of cell wall structure of the laterally-situated abaxial epidermis cells; circle = the appearance of the structural form characteristic of the developed anticlinal cell walls
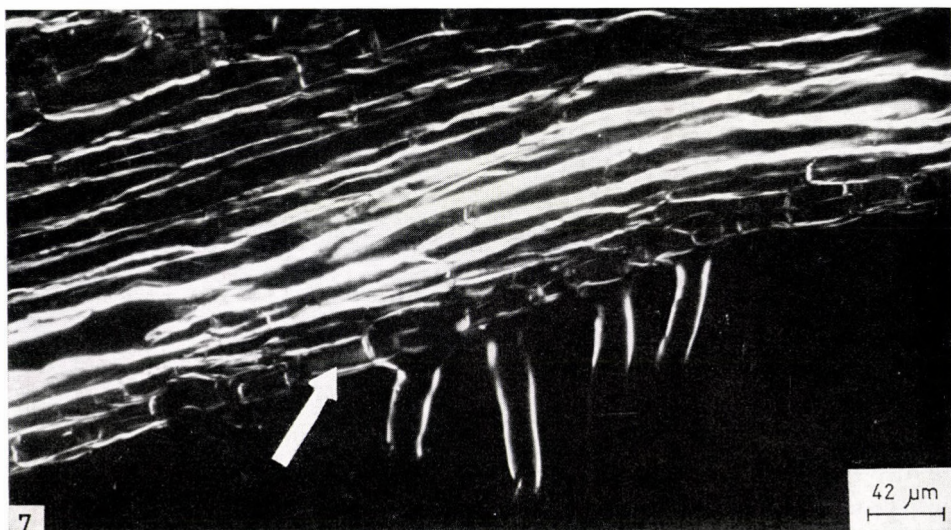
Fig. 7. The zone of origin of the smooth rhizoids, in the longitudinal section of the midrib region, between crossed nicols. On the cell walls of the abaxial epidermis cells lying in this plane, the lattice-like cell wall thickenings (arrow), which are more birefringent in their diagonal position, can be observed. Chloro-zinc-iodine staining

The smooth rhizoids

The cellulose cell wall structure of the fully developed smooth rhizoids

It is a generally accepted view that, the rhizoids function analoguously with the roots of the higher plants that is, they are "organs" of the nourishment uptake (HABERLANDT, 1918; SMITH, 1972). The difference between the function of the "smooth" rhizoids and the surrounding abaxial epidermis cells in the gametophyton of *Marchantia polymorpha* L. is shown also by their structure composed of two parts. Their basis lies between in the plane of the abaxial epidermis cells, and its form is similar to that of the epidermis cells. A long, characteristic, tube-like elongation arises perpendicularly from the basis (Fig. 7). The basal part is slightly elongated parallel with the longitudinal axis of the thallus. In this direction, their average size is 51 micrometer, their diameter perpendicular to this plane 34 micrometer, while their height is 13 micrometer. In the polarization microscopical examinations, the structure of the anticlinal cell walls of the basic cell proved to be similar to that of the cell walls in a similar position of the abaxial epidermis cells. This similarity was valid with respect to both the direction of the microfibrils of these cell walls and the pattern of thickening of these latter (Figs 7 and 8).

It occasionally occurred in preparations of longitudinal sections that the cell wall constituting the basis of the elongation of the smooth rhizoid happened
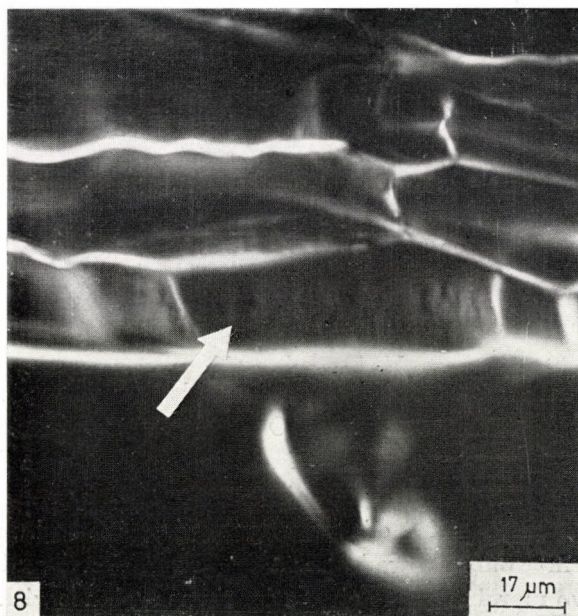
Fig. 8. Cell wall of the longitudinally lying basal part of a mature smooth rhizoid (arrow), between crossed nicols. The cell wall thickenings are of a diagonal position. Congo red staining

to be in the plane of the section and so we were able to examine it also in a view from above. When inserting first rate red sheet in the case of the polarization microscopical examination, an additional colour appeared along the side parallel with the gamma axis of the auxiliary plate, in every case, while in the direction perpendicular to it, a subtraction colour appeared. Consequently it can be said that the microfibrils in the rhizoid basic cell are of a concentric arrangement (Fig. 9).
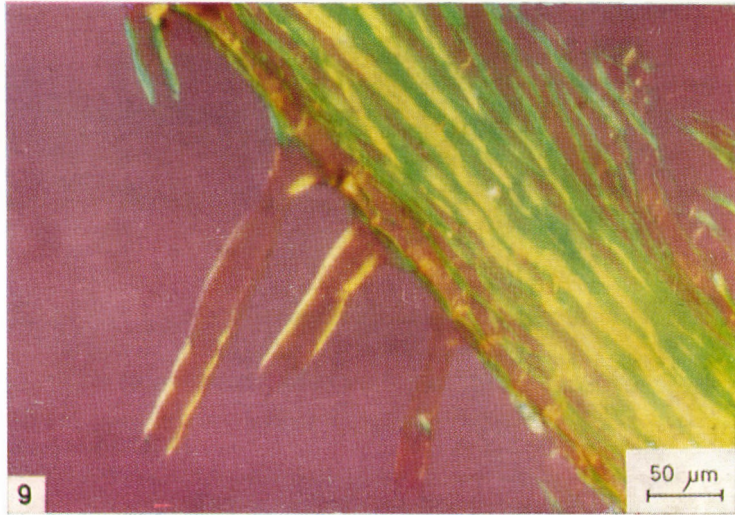
Fig. 9. The zone of origin of mature smooth rhizoids along the longitudinal section of the midrib region, between crossed nicols. With the application of a first rate red sheet. At the same time an additional colour appears in the basal part of the elongations in a subtractional position. Congo red staining

The rhizoid elongation showed extinction in North-South and East-West situations, while in a North-East and South-West situation it showed a maximum birefringence (Fig. 10). In the case of smooth rhizoids with a sinuous profile, the extinction was not uniform even in the case of orthogonal position, on the two margins of the elongation, along the dotted line, illumination was observed also later (Fig. 11). On inserting first rate red sheet, the elongation showed an additional colour in the case of a diagonal position, that is, in that parallel with the gamma axis of the auxiliary sheet. The rhizoids with sinuous walls in a position of North-South direction and under conditions similar to the former ones showed alternatively additional and subtractional colours on the two margins of the elongation, in accordance with the aforementioned dotted line. This is characteristic also of the optical behaviour of the ripe cotton hair (ROELOFSEN, 1959). On the basis of this, it can be said by

inference that in the elongation of the sinuous rhizoids, there is also a helical microfibril arrangement.

Summarily, it can therefore be stated that, depending on their position, even identical rhizoid cells can be bordered by cell walls of different skeleton structures. Obviously, these cell wall structures of different pattern owe their existence to their different functions.

It is also worthy of mentioning that the margin of the obtusely rounded
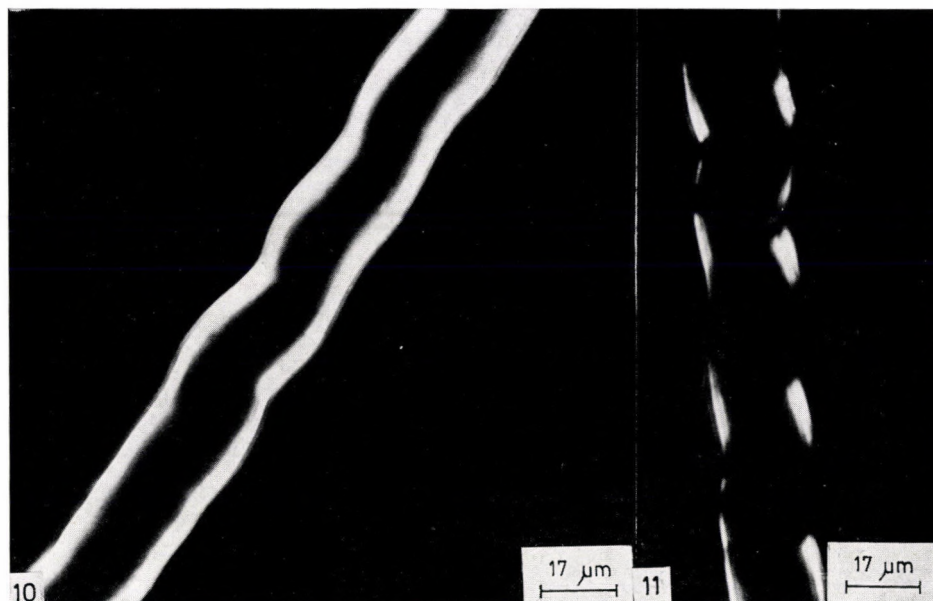
Fig. 10. Smooth rhizoid elongation of a sinuous profile, between crossed nicols, in a diagonal position

Fig. 11. The smooth rhizoid elongation shown in Fig. 10, between crossed nicols, in an orthogonal position

apical part of the smooth rhizoid shows a yellow colour on the application of the first rate red sheet, therefore a subtraction colour, in opposition to the blue colour of the margins of the diagonally situated elongation. While in a situation perpendicular to this the apex emerges in a blue interference colour. Hence in the apex part, the direction of the curvature is followed by the microfibrils as well. If examining only among crossed nicols, the birefringence of the margin of the apex, in comparison with the elongation margin, is weaker, which indicates that on this part the cell-wall is thinner or at least birefringent that is, of an arranged skeletal structure. Our results referring to the cell wall of the smooth rhizoids are summarized in Fig. 12.
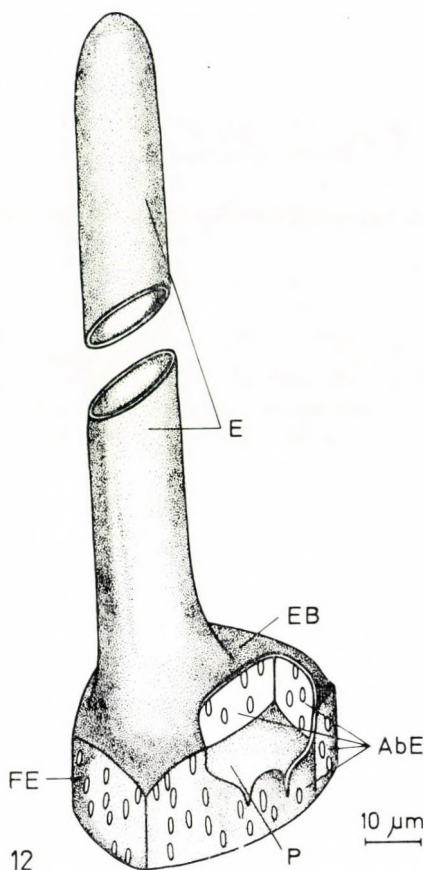
Fig. 12. Spatial picture of the smooth rhizoid cell wall structure in a *Marchantia polymorpha* L. gametophyton; *E* = elongation; *EB* = cell wall forming the basis of the elongation; *AbE* = = cell walls common with abaxial epidermis cells; *P* = periclinal cell wall occuring towards the inner side of the thallus

The cellulose cell wall structure of smooth rhizoids at a relatively young age

The basal part and the elongation of the smooth rhizoids at a young stage were examined by means of the scanning electronmicroscope. We succeeded in directly identifying a structure in the external periclinal cell wall projecting and at the same time forming the basic cell of the elongation, which was to be expected on the basis of the preceding indirect polarization examination, and which has already been described in detail when discussing this wall of the fully developed cell (Fig. 13). It can be seen in the scanning electronmicroscopic picture that around the basic part of the removed rhizoid elongation, the cellulose filaments are concentrically arranged in the larger half of the periclinal cell wall area. In part of the picture, a filament transversely

interwining the concentrically running filaments and probably organically connecting the elongation to the basal part, can also be seen (Fig. 13).

The elongated part of the young rhizoids, indicated under the polarization microscope, a microfibril orientation which is similar to that of the smooth rhizoids in the developed parts of the thallus, that is an orientation agreeing with that of the longitudinal axis of the elongation. In the case of the eventual
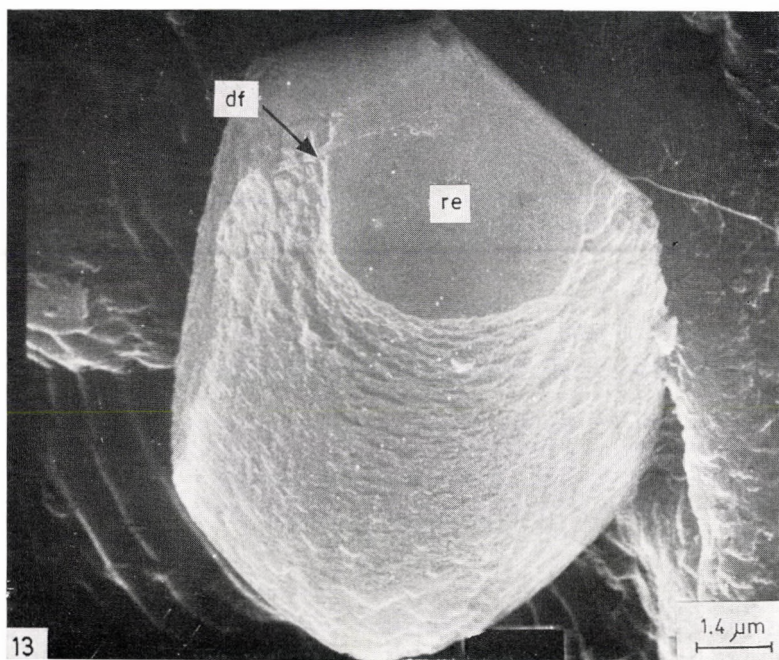
Fig. 13. Basal part of a young smooth rhizoid. Around the place of protrusion of the elongation (*re*), the fibrils are concentrically oriented in the larger half of the cover; *df* = fibril interwoven diagonally. Scanning electronmicroscopical picture

fissures of the rhizoids, which occurred in the course of preparation, it was characteristic that their direction was in agreement with the microfibrillation (Fig. 14). The speciality fine structure of the elongated part of the smooth rhizoids is indicated by the fact that not even the scanning electronmicroscopical magnification of 40.000× made an identification of the separated filaments possible. In spite of this even in the scanning electronmicroscopical picture, there can be recognized a kind of arranged state which in an indirect way corresponds to the orientation detected indirectly by means of the polarization microscope (Fig. 15).
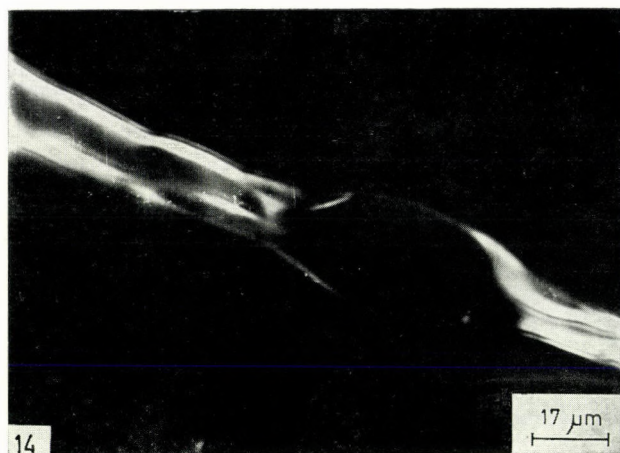
Fig. 14. Smooth rhizoid in a relatively young stage with a longitudinally ruptured wall, between crossed nicols and in a diagonal position. Congo red staining
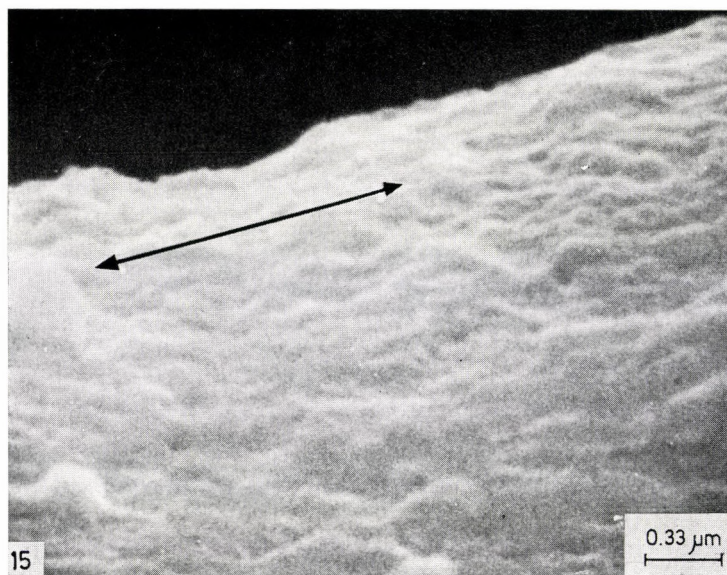
Fig. 15. Scanning electronmicroscopical picture of the outer surface of a smooth rhizoid elongation in the relatively young stage; ↔ = direction of the longitudinal axis of the rhizoid elongation

The rhizoids with tubercled cell wall thickenings

The cellulose cell wall structure of fully developed rhizoids with tubercled cell wall thickenings

The tubercled rhizoids with very special thickening of the cell wall are probably the most well-known among the cell types of *Marchantia polymorpha* L. Investigations were mainly concentrated upon their elongated part, in the course of which several authors established that the tubercles, which follow a helical course while rising from their original position, may unite with each other up to a length of a half circle or for three quarters during their rise, and this is indicated externally by the sinuous outline of the rhizoid (KÜSTER, 1956). DIPPEL (1872) held the view that the special distribution of the protoplasm caused the special thickening of the wall, and so also the tubercled thickening of the cell wall.

The examination of the basal part inserted among the abaxial epidermis cells of the tubercled rhizoids was on the other hand rather neglected. This basal part is similar in shape to that of the abaxial epidermis cells, its length is 60 micrometer and its diameter 29 micrometer. The tubular part, with diameter of 9—16 micrometer and a length of some 2 mm, protrudes from it, aligned to the ventral side of the thallus (Fig. 16). The tubular elongation becomes extinct between crossed nicols in a position of North-South and East-West direction, while a maximum birefringence is produced by it in its
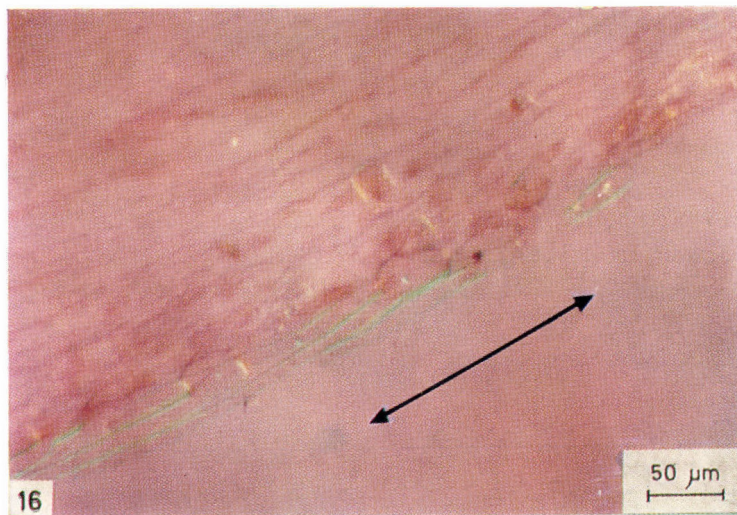
Fig. 16. Origin of tubercled rhizoids at a distance of 1200 micrometer from the growing apex of the thallus. Longitudinal preparation, between crossed nicols, by inserting a first rate red sheet. Congo red staining; ↔ = direction of the gamma axis of the first rate red sheet

North-East and South-West position (Fig. 17). By inserting the first rate red sheet it could be determined that the direction of the greatest refractive index of the cell wall was parallel with the longitudinal axis of the cell. Similarly as in the case of natural fibres, it was especially on the two longitudinal margins of the rhizoid that the additional colour manifested itself strongly. Certain tubercled rhizoids, however, did not produce a complete extinction even in their orthogonal position, but similarly to the smooth rhizoids of a sinuous
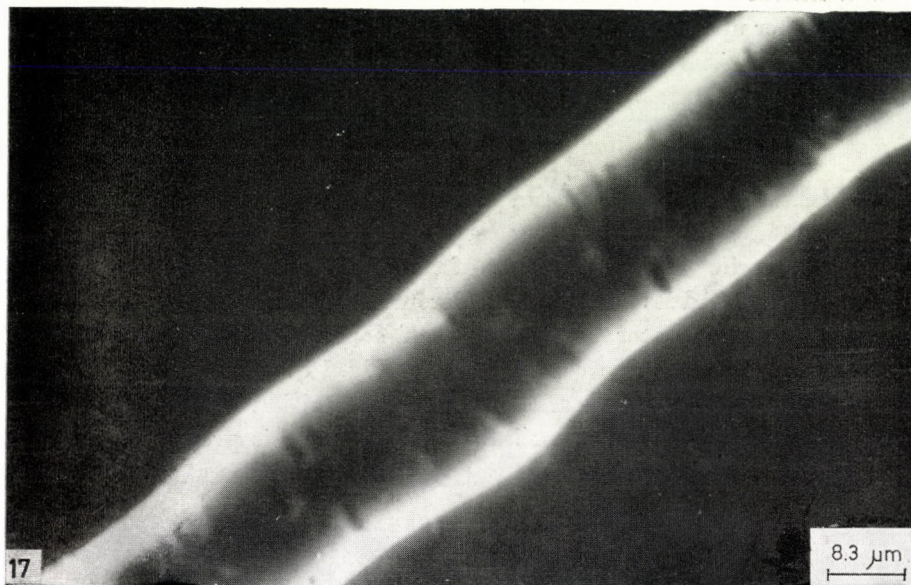
Fig. 17. Tubercled rhizoid elongation in a developed stage, between crossed nicols, in a diagonal position. Congo red staining

profile, they continued to luminesce in a broken line along their margins (Fig. 18). It can be inferred from this that their microfibrils might become arranged in a helical course. This inference is supported by the fact that when inserting the first rate red sheet, the margins of the cell wall alternatively show additional and subtractional colours, in accordance with the illuminating broken lines.

The determination of the microfibril orientation occurring in the tubercles was carried out in double-walled tubercled rhizoids. By applying a narrow condensor-opening, between crossed nicols, four luminescent light-spots emerged at the root of each tubercle in the North-South position of the rhizoids (Fig. 18). On a diagonal position of the first rate red sheet, in relation to the main axis of it, the yellow colour of the two marginal light spots and at the

same time the other two light spots on the opposite side indicated that the microfibrils become radially arranged in the tubercles (Fig. 19).

The region of the rhizoid wall which is a transition between the cover and the basal part of the elongation was studied separately. The polarization microscopical examination indicated an arranged structure also in this part of the cell wall. Under the effect of the first rate red sheet, the additional colour was in agreement also in this mouth of the rhizoid elongation with that of the
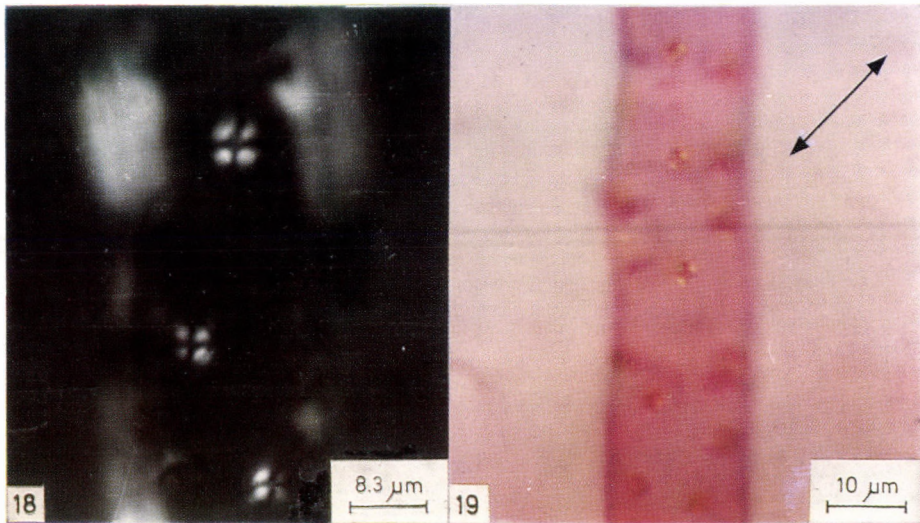
Fig. 18. Mature tubercled rhizoid elongation, between crossed nicols, in an orthogonal position At the root of the tubercles, luminescent light spots, four at each, are observable. Congo red staining

Fig. 19. Rhizoid elongation and its situation, same as in Fig. 18, with the application of a first rate red sheet; ↔ = the direction of the gamma axis of the first rate red sheet

longitudinal axis of the elongation. From this is follows that the microfibrils of the cover are arranged parallel with the longitudinal axis of the rhizoid elongation, the cover, and with the direction of the longitudinal growth of the thallus.

In preparations of longitudinal sections, there are tubercled thickenings, similar to the tubercles of the elongation on the cell wall of the opened inner surface of the anticlinal cell walls of also the basal part and also on the inner surface of the cover (Fig. 20). Our data on the cellulose cell wall skeleton of the matured rhizoids with tubercled thickenings of the cell wall are summarized in Fig. 21.
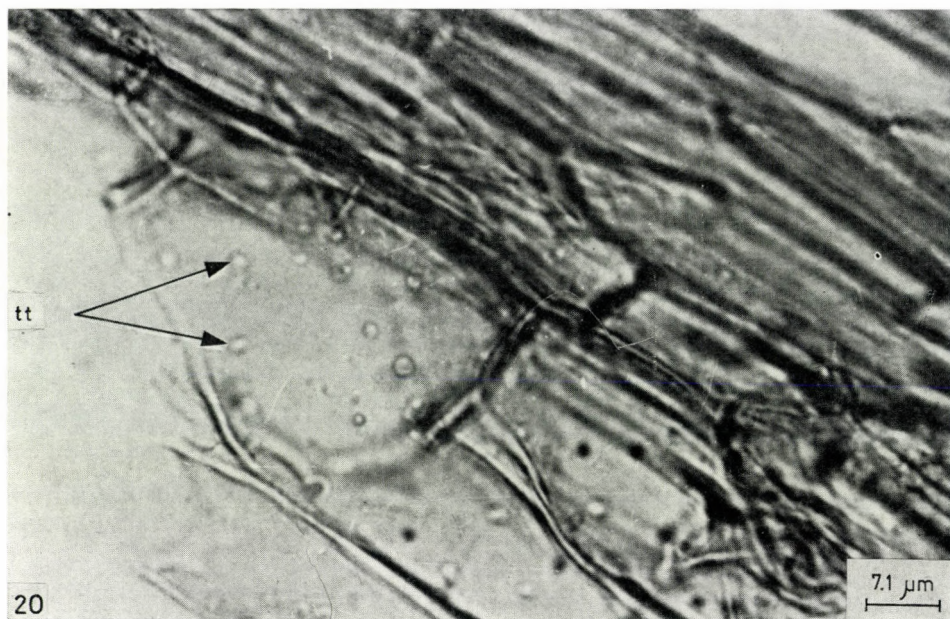
Fig. 20. Longitudinal section of part of the midrib-like elevation, showing the origin of the tubercled rhizoids; *tt* = tubercled thickening of the cell walls of the basal part
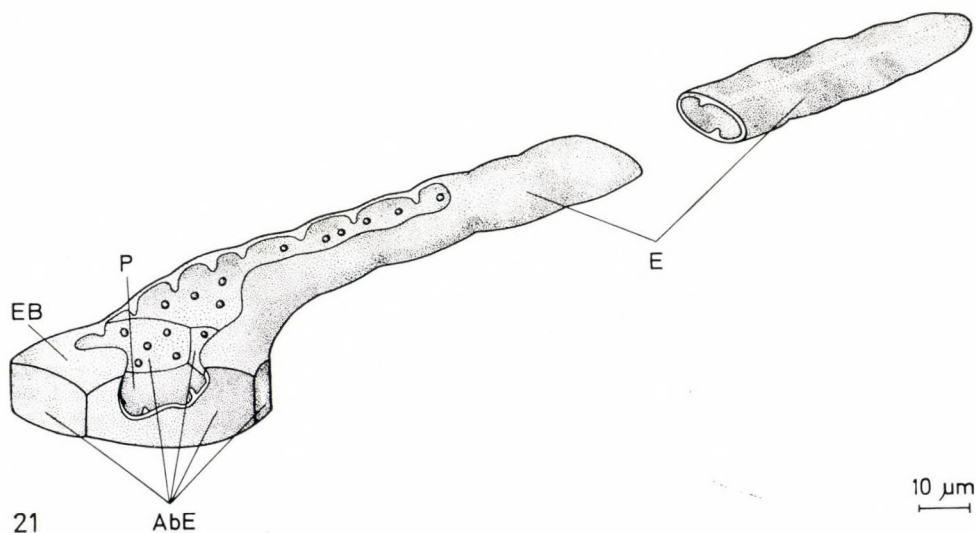
Fig. 21. Spatial picture of the structure of the tubercled rhizoid in a *Marchantia polymorpha* L. gametophyton; *E* = elongation; *EB* = cell wall part forming the basis of the elongation; *AbE* = cell walls in common with abaxial epidermis cells; *P* = periclinal cell wall occuring towards the inner side of the thallus

The growth and differentiation of the cellulose structure of the rhizoids with tubercled cell wall thickenings

Of the two rhizoid types occuring on the thallus of *Marchantia polymorpha* L., we traced the growth and differentiation of the cellulose cell wall structure of the "tubercled" rhizoids; since the characteristic thickenings allow a better observation of the process development.
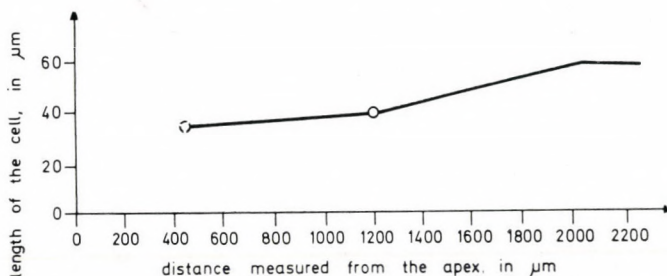
Fig. 22. Correlation between the longitudinal growth of the basal part of tubercled rhizoids and the formation of the cell wall structure; circle with dashed line = appearance of the characteristic tubercles of the anticlinal cell walls; circle with continuous line = definite presence of the characteristic tubercles of the anticlinal cell walls

The basal part of the "tubercled" rhizoid, situated at a distance of 450 micrometer from the growing apex of the thallus, has a length of 36 micrometer and a diameter of 9 micrometer; the length of its elongation is 400—600 micrometer, 9 micrometer in diameter. In the still undeveloped rhizoids, occurring at the aforementioned phase, the primordia of the tubercled thickenings are already observable by means of the polarization microscope. At the same time, the microfibrils are also observably arranged in the cell wall of the elongation, in the direction of its longitudinal axis, which is characteristic also of the developed rhizoids (Fig. 16).

The length of the basic part of the tubercled rhizoids, originating at a distance of 1200 micrometer from the apex, is 39 micrometer, its diameter 21 micrometer; the diameter of its elongation is 9 micrometer also here. The tubercles can definitely be seen in this region and even their radial structure can be observed. The tubercled rhizoids which lie at a distance of 2000 micrometer from the apex reach sizes characteristic of their mature state (the length of the basic part is 60, its diameter 29 micrometer, the diameter of the elongation fluctuates between 9—15 micrometer, while its length is about 2000 micrometer). Therefore, while the length of the basic part increases merely twice to its original size in this section, the increase in length of the elongations is

fivefold. In Fig. 22 a graph of the increase in length of the basal part, while in Fig. 23 that of the elongation, are shown, in connection with the formation of the characteristic tubercled thickening of the cell wall.
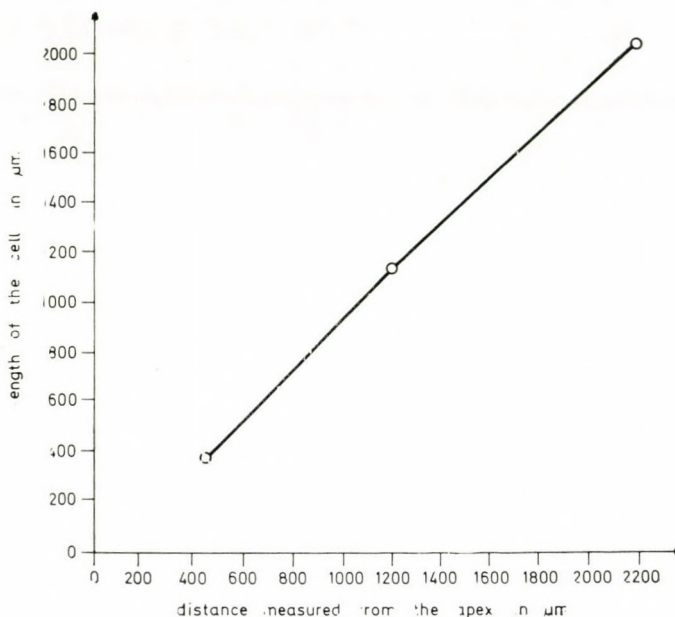
Fig. 23. Correlation between the longitudinal growth of tubercled rhizoid elongation and the formation of the cell wall structure; circle with dashed line = appearance of the tubercled cell wall thickenings; circle with continuous line = definite presence of the tubercled cell wall thickenings

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CORRELATION BETWEEN ABOVE-GROUND PHYTOMASS PRODUCTION AND THE CHLOROPHYLL CONTENT IN THE VEGETATION OF A "LÖSZPUSZTARÉT", IN FIELD EXPERIMENTATION AND IN CONDITIONED SITUATIONS

By

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We examined the correlation between the above ground phytomass production and the chlorophyll content in the dominant species of four stands in the plant association of the loess puszta meadow ("löszpusztarét", *Salvio-Festucetum rupicolae pannonicum* Zólyomi, 58), in field experiments and in conditioned circumstances (in photostat). We pointed out a close positive linear regression relation between the phytobiomass production and the chlorophyll content of the production calculated for dry weight, concerning the closeness of the correlations, there was no essential deviation between the values of field experiments and those of conditioned circumstances.

Introduction

The correlation between the chlorophyll content of plant associations and their production was examined by several authors (for example Gessner, 1949, 1959; Bray, 1960, 1962; Brougham, 1960; Medina-Lieth, 1964; Ovington-Lawrence, 1967) — primarily with regard to aqueous vegetations; concerning — terrestrial vegetations, the question is rather untreated; Fekete (1972) provides a critical survey of them. We have already published data on the correlation between organic matter production, the photosynthetic energy utilization and the chlorophyll content in relation to plant stands of salt soild (Horváth—Bodrogközy, 1973). At present we examine the organic matter production and photosynthetic energy utilization of the vegetation of a löszpusztarét (*Salvio-Festucetum rupicolae pannonicum* Zólyomi, 58), in field experiment (Endrédi—Horváth, 1976), and in conditioned circumstances. The present paper submits the results related to the correlations between the dry matter production and the chlorophyll quantity corresponding to it for above-ground living plant parts (= phytobiomass — Précsényi, 1975) in the species occurring in the greatest quantity or dominant in the plant stands of the löszpusztarét.

Material and method

The vegetation examined consisted of the following stands of the *Salvio-Festucetum rupicolae pannonicum* Zólyomi, 58 (Soó, 1964; 1973) association, which occur on the western slopes of Nagyhegy at Dunaföldvár (ENDRÉDI—HORVÁTH, 1976):

1. *S.-F. r. p.* Zólyomi, 58 *festucetosum rupicolae;*
2. *S.-F. r. p.* Zólyomi, 58 *stipetosum capillatae* Soó, 59;
3. *S.-F. r. p.* Zólyomi, 58 *andropogonetosum* (Boros, 53) Soó, 59;
4. *S.-F. r. p.* Zólyomi, 58 *poëtosum angustifoliae* Zólyomi, 59.

The field experiments of the plant stands were made from the beginning of April till the end of September, 1975. The stands of the experimental area were at the start of the investigations — April 2, 1975 — mowed down and the plant material removed. Subsequently (till the end of the vegetation period), the above-ground phytobiomass of the plant stands which was growing undisturbed was sampled by the mowing method (ODUM, 1959), at the points of time indicated in Table 1.

We took samples at random from four areas of 25×25 cm each in the sampling areas at a time; in the calculations we worked with the average of the four repetitions. The material of the samples was dried at 80 °C up to a constant weight, and the dry matter quantities thus obtained were recalculated for 1 m^2 area units.

Each of the plant stands was examined also among conditioned circumstances, in the photostat made by us (ENDRÉDI—HORVÁTH, 1975). Three pieces of "grass cubes", 20×20××20 cm each, were cut from the plant stands; at the beginning of the investigation the vegetation was cut back to the surface of the ground also in these cases; the material was placed into stand-boxes and put into the photostat.

The temperature in the photostat was 18—28 °C in a daily rhythm, the relative vapour content of the air varied between 45—80%; as a result of continuous ventilation CO_2 concentration was practically constant and it was in agreement with the natural concentration (0.03%). By daily watering with destilled water, an approximately identical water supply was guaranteed for the vegetation during the investigations. Light was provided by means of 40 kW F_{33} fluorescent tubes, for 12 hours daily. The light density was about 12 000 lux, which corresponds to about 10.5 cal · cm^{-2} · h^{-1} energy. This, during the 180 day experimental period, amounted to total of 22 680 cal · cm^{-2} energy. At the same time, in field conditions, the plant stands received about 69 700 cal · cm^{-2} global radiation. (The datum is obtained from the measurements of the Agrometeorological Observatory at Martonvásár-Erdőhát, a station of the Central Institute for Aerological Physics — situated at a distance of about 50 km from the experimental area; for kind permission of using the data thanks are due to the head of the observatory, Dr. János PLETSER.

The investigations in conditioned circumstances were made from April 1 to September 28, 1975; sampling times are included in Table 1. The periods of investigations are in agreement with those of field experiment.

Table 1

Times and periods of investigations

No.	Sampling times		Time (days) elapsed	
	Field experiment	In the photostat	between two samplings	from beginning of testing
1	April 30	April 29	28	28
2	May 31	May 30	31	59
3	June 30	June 29	30	89
4	July 31	July 30	31	120
5	August 31	August 30	31	151
6	September 29	September 28	29	180

The taking of samples was identical with that used in field experiments; the vegetation was cut down in half of the area of the culture boxes (2 dm^2) at a time. Thus, the application of three culture boxes by stands made it possible to take samples six times.

The chlorophyll content of the species was determined at the time of the sampling (Table 1), so that we were also able to observe the seasonal changes in the chlorophyll content during the period of investigations. Photosynthetic pigments were removed from the fresh plant material — repeating it five times — by means of acetone; for rinsing petrolether was used. The absorption of pigment-extract was measured with Spekol photometer at 647 and 664 nm wave lengths the quantity of chlorophyll was determined according to ZIEGLER and EGLE (1965), by means of the following equation:

Chlorophyll a + b = $7.01 \cdot A_{664} + 17.76 \cdot A_{647}$ mg $\cdot$ l^{-1}.

In our calculations, we used the average values of the repeated investigations.

The correlations between chlorophyll content and phytobiomass production were examined by means of regression analysis; besides, significance calculations were also made (SVÁB, 1973).

The species composition and cover of the plant stands examined were nearly identical with respect to field experiments and conditioned circumstances. In our study, we considered the following species:

— *S.-F. r. festucetosum rupicolae: Festuca rupicola;*
— *S.-F. r. stipetosum capillatae: Stipa capillata* and *Salvia nemorosa;*
— *S.-F. r. andropogonetosum: Bothriochloa (Andropogon) ischaemum;*
— *S.-F. r. poëtosum angustifoliae: Poa angustifolia* and *Achillea collina.*

These species took the greatest share in the above-ground phytobiomass production of our stands examined; their average shares are shown in Table 2.

The number of other species forming the stands was between 10 and 30.

Table 2

Average share of the plant species examined in the above-ground phytobiomass production

Species	Average share in the above-ground phytobiomass production (3)	
	Field experiment	In the photostat
Festuca rupicola	65.35	63.78
Stipa capillata	56.46	43.90
Salvia nemorosa	13.45	26.51
Bothriochloa ischaemum	62.87	72.00
Poa angustifolia	39.26	39.02
Achillea collina	13.90	38.83

Results

The seasonal changes in chlorophyll concentration calculated for dry weight in the plant species examined of the löszpusztarét are shown in Fig. 1.

Chlorophyll content essentially showed identical changes in field experiments and in conditioned circumstances during the period of investigations. Differences in general arise from the fact that in the great majority of the species stands grown in the photostat (*Festuca rupicola, Stipa capillata, Salvia nemorosa, Achillea collina*) the highest chlorophyll concentration developed
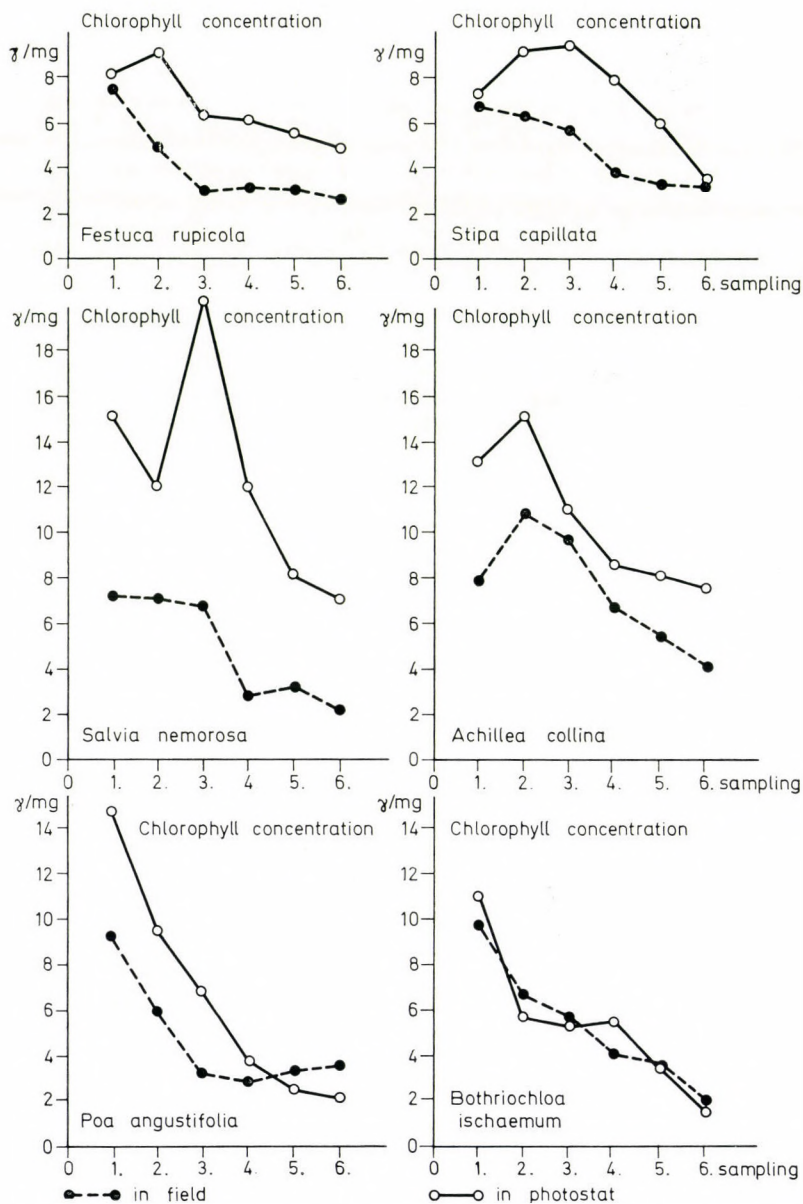
Fig. 1. Chlorophyll concentrations at the sampling times, calculated for the dry weight

not at the beginning of the growth period, but later, while in the case of field experiments this was experienced only with *Achillea collina*. Chlorophyll content in general in the lowest at the end of the vegetation period, with the exception of the field stand of *Poa angustifolia*.

The above-ground phytobiomass production values and the corresponding chlorophyll quantities in the various sampling periods are given in detail in Table 3 and demonstrated in Figs 2, 3.

Table 3

The quantity of the above-ground phytobiomass production and the chlorophyll content of the phytobiomass at the experimental points of time

Species	Sampling times	Above-ground phytobiomass production (g/m^2)		Chlorophyll content of phytobiomass (mg/m^2)	
		In field	In photostat	In field	In photostat
Festuca rupicola	1.	15.84	39.71	121	328
	2.	85.75	135.56	433	1246
	3.	161.00	207.50	506	1344
	4.	112.00	237.58	359	1493
	5.	85.75	168.42	274	956
	6.	58.75	133.97	157	669
Stipa capillata	1.	18.55	25.36	129	189
	2.	148.62	81.12	980	750
	3.	373.00	133.93	2205	1281
	4.	341.60	162.53	1733	1304
	5.	358.00	132.50	1280	820
	6.	163.50	131.52	574	496
Salvia nemorosa	1.	13.34	19.24	97	292
	2.	31.62	54.70	228	660
	3.	63.65	90.69	440	1741
	4.	92.80	118.14	267	1426
	5.	63.20	87.42	205	714
	6.	16.65	15.63	38	111
Bothriochloa ischaemum	1.	17.20	47.97	169	533
	2.	112.75	189.24	780	1098
	3.	362.63	257.55	2161	1415
	4.	431.80	420.30	1820	2430
	5.	190.50	225.42	715	805
	6.	42.50	40.53	92	67
Poa angustifolia	1.	18.70	60.75	174	903
	2.	150.25	103.59	914	995
	3.	261.85	118.44	885	708
	4.	197.65	89.98	605	342
	5.	137.67	81.20	474	214
	6.	99.82	71.74	365	163
Achillea collina	1.	10.30	27.50	82	361
	2.	38.75	79.67	422	1254
	3.	55.00	116.26	500	1295
	4.	74.88	126.64	520	1094
	5.	55.25	98.50	311	805
	6.	48.34	94.39	209	728
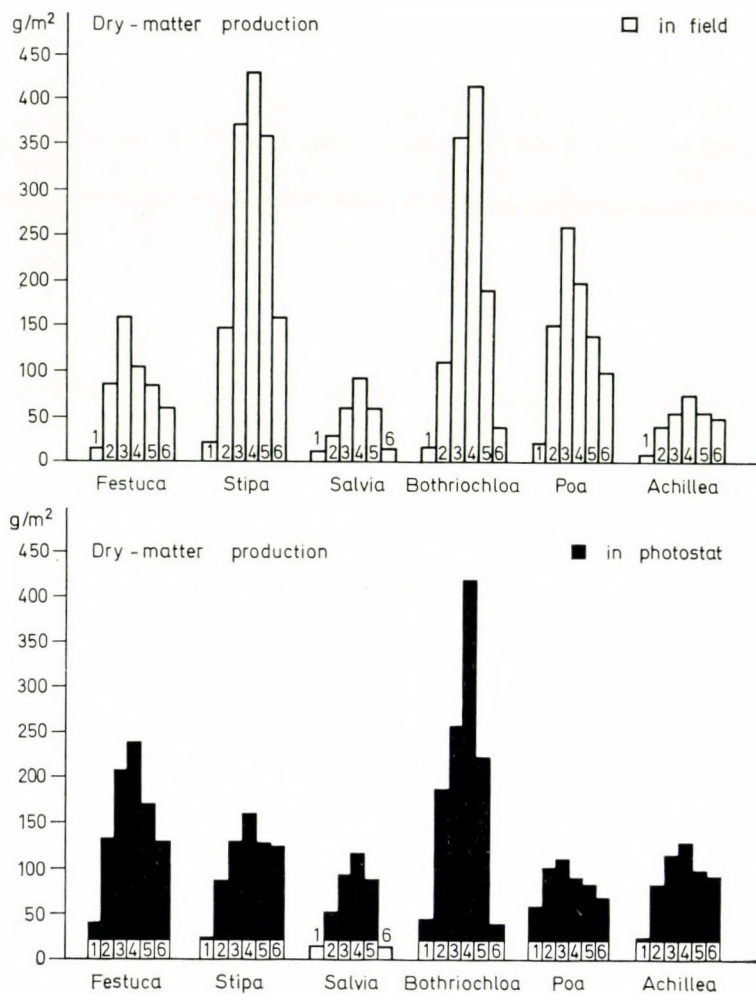
Fig. 2. Above-ground phytobiomass productions in the testing periods

Discussion

On the basis of our results concerning the above-ground living parts of the plant species which are dominant or share in the vegetation to the greatest proportion of a löszpusztarét, the following inferences can be drawn.

The chlorophyll concentration calculated for the dry weight was higher in the photostat than in field experiments (Fig. 1) for ***Botriochloa ischaemum*** and ***Poa angustifolia***, however, no significant differences could be shown (Table 4). (Significance calculations were made by using the data shown in
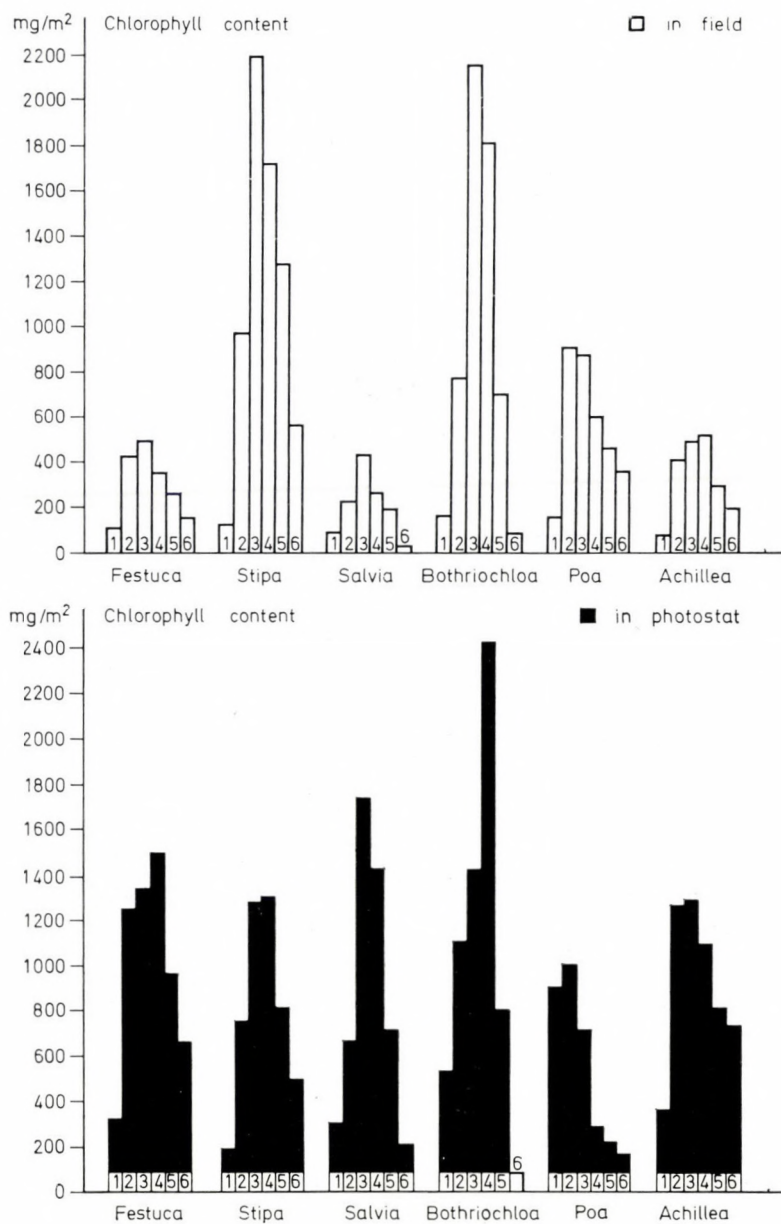
Fig. 3. Chlorophyll quantities in the above-ground phytobiomass productions at the testing times

Table 4

Results of the significance tests of chlorophyll concentrations calculated for dry weights

Species	Chlorophyll concentration calculated for the dry weight (R/mg)				
	Mean values		Difference of mean values	Significant difference (SD)	Probability level (P)
	In field	In photostat			
Festuca rupicola	4.15	6.81	2.66	1.96	1%
Stipa capillata	5.09	7.37	2.28	1.65	5%
Salvia nemorosa	4.97	12.29	7.32	5.03	1%
Bothriochloa ischaemum	5.47	5.57	0.10	—	—
Poa angustifolia	4.82	6.53	1.71	—	—
Achillea collina	7.48	10.75	3.27	2.38	1%

Fig. 1.). The situation is the same in the chlorophyll quantities corresponding to the dry matter production per unit of area (Tables 3 and 5).

The higher chlorophyll content in conditioned circumstances is the consequence of a lower level of light energy. The differences among species are probably explainable by their different light demands. The conditioned circumstances differently influenced the phytobiomass production of the examined plant species. The dry-matter production per unit of area — with identical cover in *Festuca rupicola*, *Salvia nemorosa* and *Achillea collina*, was considerable more in the photostat than in the field experimentats, while in *Stipa capillata* and *Poa angustifolia* the production value in field experiments was significantly higher. In the two kinds of *Bothriochloa ischaemum* stands there was no essential difference in relation to the quantity of dry matter production (Tables 3, 6).

Table 5

Results of the significance tests related to the chlorophyll content of above-ground phytobiomass

Species	The chlorophyll content of the above-ground phytobiomass production (mg/m²)				
	Mean values		Differences of mean values	Significant differences (SD)	Probability (P)
	In field	In photostat			
Festuca rupicola	303.33	1006.00	702.67	519.58	1%
Stipa capillata	1150.14	806.67	343.50	286.63	10%
Salvia nemorosa	212.50	824.00	611.50	531.14	5%
Bothriochloa ischaemum	956.17	1058.00	101.83	—	—
Poa angustifolia	569.50	554.17	—15.33	—	—
Achillea collina	340.67	922.83	582.17	575.93	0.1%

In the correlation analyses, we considered the above-ground phytobiomass production per unit of area, and the chlorophyll quantities corresponding to them (Table 3). The results of the regression analysis are given in Table 7 and in Figs 4, 5.
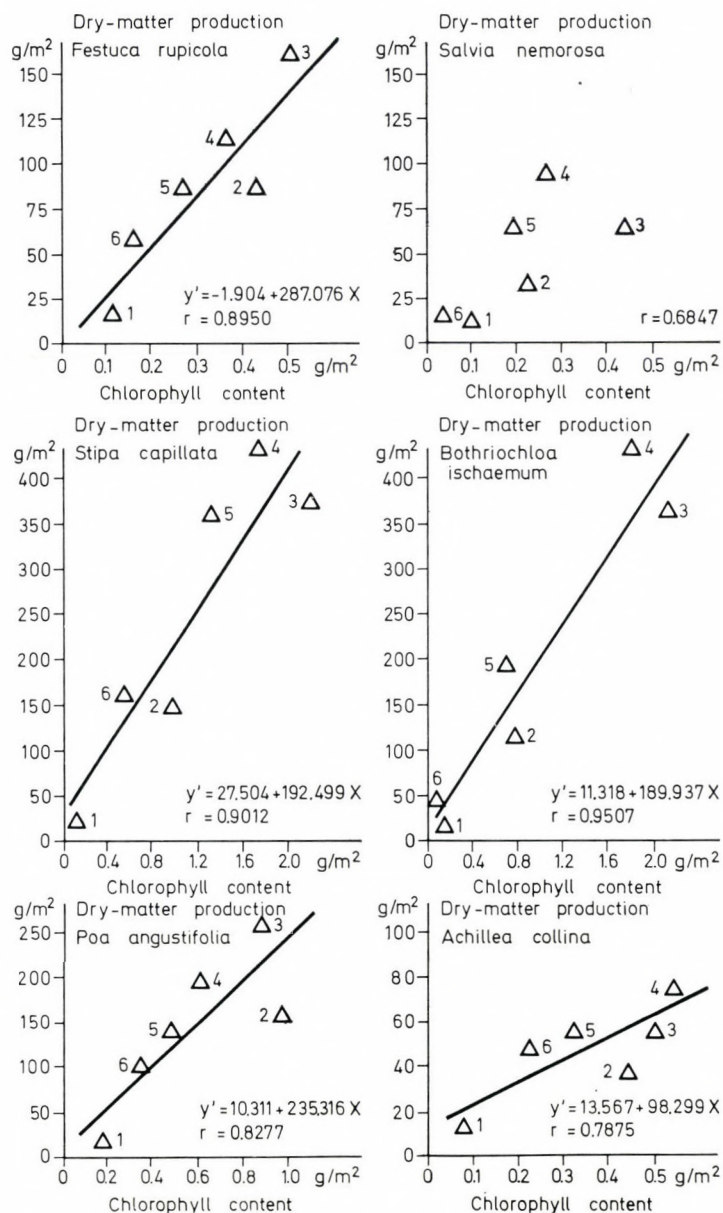
Fig. 4. Correlations between above-ground phytobiomass productions and chlorophyll quantities in the plant stands of field experiments

According to our investigations, there is a close positive linear regression relation between the dry-matter production and the chlorophyll content — with the exception of the *Salvia nemorosa* stand grown in field experiments and that of *Poa angustifolia* in conditioned circumstances.
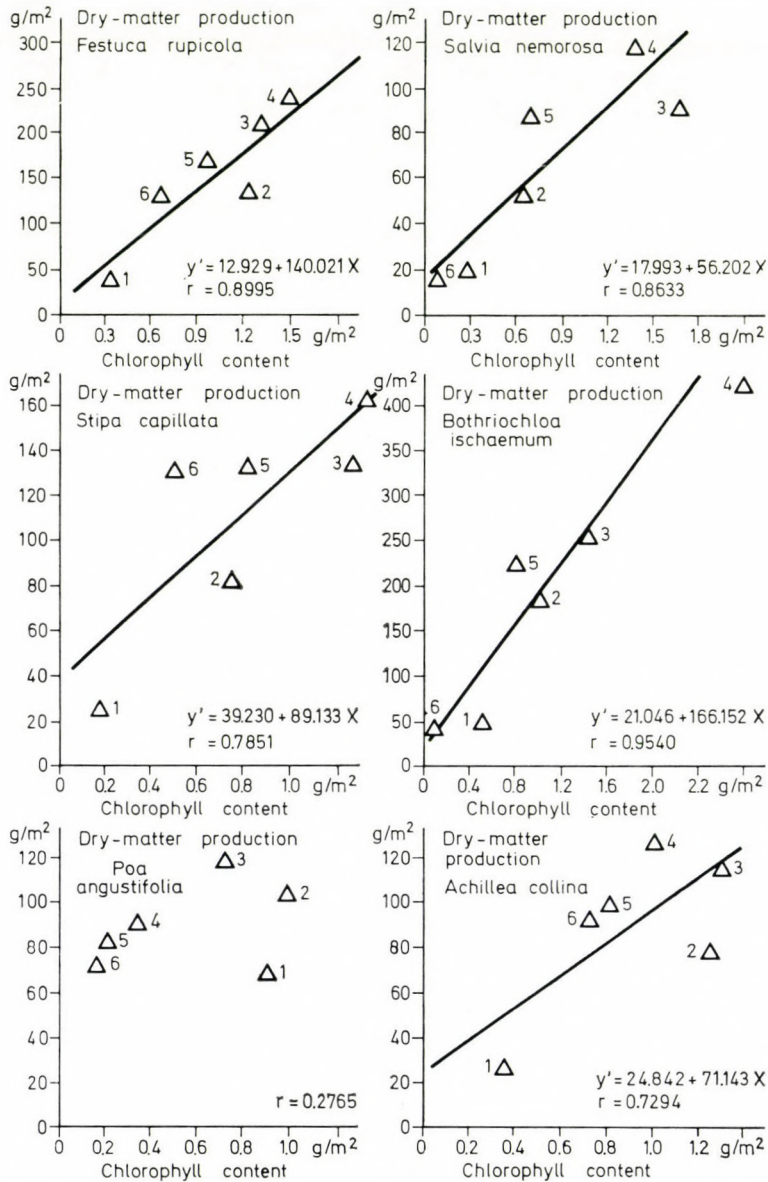
Fig. 5. Correlations between the above-ground phytobiomass productions and the chlorophyl contents in plant stands grown in photostat

Table 6

Results of significance tests related to above-ground phytobiomass production

Species	Phytobiomass production above-ground (g/m^2)				
	Mean values		Differences of the mean values	Significant differences (SD)	Probability level (P)
	In field	In photostat			
Festuca rupicola	86.51	153.79	67.28	58.49	1%
Stipa capillata	248.88	111.16	—137.72	—126.10	5%
Salvia nemorosa	46.88	64.30	17.42	12.47	5%
Bothriochloa ischaemum	192.90	196.83	—3.93	—	—
Poa angustifolia	144.32	87.62	—56.70	—53.17	10%
Achillea collina	47.09	90.49	43.40	41.32	0.1%

Table 7

Results of the regression analysis of above-ground phytobiomass production and of the chlorophyll content

Species	Correlation between above ground phytobiomass production and the chlorophyll content			
	Correlation coefficient (r)		Probability level of significance (P)	
	In field	In photostat	In field	In photostat
Festuca rupicola	+0.8950	+0.8995	2%	2%
Stipa capillata	+0.9012	+0.7851	2%	10%
Salvia nemorosa	+0.6847	+0.8633	Not significant	5%
Bothriochloa ischaemum	+0.9507	+0.9540	1%	1%
Poa angustifolia	+0.8277	+0.2765	5%	Not significant
Achillea collina	+0.7875	+0.7294	10%	10%
Mean values	+0.8411	+ 0.7513	—	—
Differences in mean values	0.0898		Not significant	Not significant

The close correlation between the above-ground phytobiomass production and the chlorophyll content of the production is proven also by the fact that in our experiments, for the plant species in which the considerably less light energy in the photostat was accompanied by a large-scale increase in the chlorophyll concentration calculated for the dry matter weight, the organic-matter production in general also became considerably higher than that in field experiments. An exception to this is, however, *Stipa capillata*, the productivity of which was unfavourably influenced by the conditioned circumstances. Concerning the closeness of the correlation, it is worthy of attention that in

Bothriochloa ischaemum the nearly identical chlorophyll content in the field experiments and in conditioned circumstances resulted in virtually identical quantities of above-ground phytobiomass production.

Summary

We examined the correlation between the organic matter production of above-ground living parts and the chlorophyll content in dominant species which take the greatest share in the dry-matter production of four stands of the plant association of a löszpusztarét (*Salvio-Festucetum rupicolae pannonicum* Zólyomi, 58). The investigations were made for 180 days, sampling in general at 30 day-intervals, in field experiments and in conditioned circumstances. The latter were prepared in photostats devised by us. The plant stands were light for 12 hours per day at 12 000 lux light intensity in the photostat. Chlorophyll concentrations were determined from the fresh material, then they were calculated for dry weights. The species composition and cover of the plant stands examined in field experiments and in conditioned circumstances were virtually identical.

The following inferences can be drawn:

1. In the photostat, the lower energy level of light resulted in a chlorophyll concentration higher in general than that in field experiments.

2. The above-ground phytobiomass production was significantly higher in three species (*Festuca rupicola, Salvia nemorosa* and *Achillea collina*) in conditioned circumstances, and in two species (*Stipa capillata* and *Poa angustifolia*) in field experiments, while in *Bothriochloa ischaemum* there was no essential deviation.

3. There is in general a close positive linear regression relation between the above-ground phytobiomass production and the chlorophyll content of the production, both in field experiments and in conditioned circumstances.

4. Concerning the closeness of the correlation no significant differences were found between the plant stands grown in the field and those in conditioned circumstances.

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ALGAL SPECIES DIVERSITY IN TWO EUTROPHIC FISHPONDS

PART I. SPECIES-INDIVIDUAL LEVEL

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The Shannon measure of species diversity of the plankton algae approaches its possible maximum ($\log_2 s$) to a smaller extent in a more eutroph lake than in a less eutroph one, and also its absolute size is smaller. In a considerable part of the year, diversity is determined by the species number ($r^2 = 0.5089$), which on the other hand is highly correlated with the duration of sunshine ($r = +0.7134$ p $< 0.1\%$ $Y = 5.8912 +$ $+ 0.1810X$), but lower with insolation ($r = 0.6161$ p $< 1\%$). In a smaller part of the year, evenness plays a dominant part in the changing of diversity, if $\varepsilon < 0.2$. This period falls to the time of the alga-maximum and the nutrient limitation accompanying it. The selective inhibiting influence of the blue-green algae, which proliferate at that time of year and decrease the evenness, is also presumable. The average species number is higher, the average evenness is lower in a more eutroph lake, and both tendencies take a stronger course in the period of higher number of algae (above 100 millions of ind. per liter). The Margalef index is correlated with the Shannon index. The parameters calculated with a higher accuracy (H, R, J) did not provide considerably better results, since the algal data counted by means of the traditional algological method provided a false statistical accuracy. The results are demonstrated in a new-type column diagram.

In my article on the examination of the two fishponds (Hajdu, 1974) I also attempted to characterize the structure of the community. "It is a very characteristic phenomenon that in summer, in the more eutrophic lake, a *Chlorophyta* arrives at a saliently high dominance, while the species number of the population remains the same, or it increases only slightly." This was such a conspicuous characteristic that the trend appeared even from the table. By analysing the structure of the association with a finer method (diversity examination), a considerably greater number of characteristics can be recognized and even the possibility of researching for correlations with the various ecological factors arises. If the table of data is regarded as an implicit function, then the diversity index is (one of) the explicit function form.

Algologists have for a long time endeavoured to provide their data in a more easily intelligible, more explicit, and therefore in an expectably more valued form.

In algology, there are significant traditions of qualifying on the basis of the so-called bioindicators. In that, the individual species of the community — the bioindicators — are paid special attention, when from their presence inferences are drawn with respect to certain characteristics of the environment.

In these cases, however, more or less of the species are left out of consideration; species which on the given level of our knowledge are not considered as indicators, or, more exactly, we have not yet recognized what they indicate. The indicator method has several disadvantages and one of the most significant is that the number of the species which are considered as indicators is insignificant in comparison with that of the other species which may emerge. The indicator species, in most of the cases, were "calibrated" by way of experience when they were in community; it was only in the rarest cases that they were supervised in axenic cultures. The indicators are always participants of a dynamic community; they reflect the characteristics of not only the anorganic, but also of the biotic environment, therefore, by working with indicators, the information can be obtained on the level of the community and not from an "autecological" source. The most widespread product of the indicator conception in hydrobiology is the saprobiological system, which by means of a rather insensitive scale provides information on the level of the saprobe content. The restrictions of saprobiology become to a considerable extent evident by the fact that in both of the two fishponds examined the saprobity indices calculated on the basis of algae were beta-mesosaprobic (HAJDU, 1974), whereas one of the ponds was constantly receiving fertilizers from the goosery situated on its shore. The true field of application of the saprobity index is in the indication of the organic contamination which rapidly changes in space and time, or is of a great quantity. The list of the trophy indicators is much more modest than even that (cf. HOOPER, 1969). The method of community structure analysis increasingly gains ground also in algology. One of its most widespread kinds is diversity examination. In opposition to the saprobity index, the diversity index is much more sensitive and exact, because it is more mathematized and informs us on the total effect of all environmental factors influencing living beings. This advantage is at the same time a disadvantage to a certain extent, because the effect of the factors can be separated only if they are measured separately and can be correlated with the diversity index. One of the best methods of examining the process of eutrophication from the algological side (HOOPER, 1969) is the diversity analysis.

Material

It was reasonable to choose an eutrophic water, a fishpond, to examine how trophy affects diversity. In this country, researches concerning fishponds can, as a result of primarily the work of HORTOBÁGYI, look back to a fine tradition (HORTOBÁGYI, 1950, 1957, 1958, 1959, 1963, 1965, 1967). These examinations can provide a useful basis for recent eutrophication investigations. The description of the two fishponds examined and the way of sampling is to be found in a previous paper (HAJDU, 1974), where the quantitative data were published.

Methods

It is known (HAIRSTON, 1959, HURLBERT, 1971, SHELDON, 1969) that the species number of the sample depends on the number of individuals actually counted in the sample, therefore, as far as possible, identical sample sizes should be used. This requirement is especially valid for the BRILLOUIN index (PIELOU, 1975, MOSS, 1973): the SHANNON index is to a great extent insensitive with respect to the size of the sample. When processing the material of the fishponds, the primary aim is to obtain quantitative data; the existing data are subsequently evaluated for their diversity. In the quantitative work we use the total number of algae (N), which changes as usual, since the quantities of algal density and of the abioseston in the individual samples are different. In the 2 ml UTHERMÖHL chamber it is usually a diagonal which is counted through, and then each of the algae is recorded by species. From the list thus obtained, we choose the species of which fewer than 50—100 specimens were found and for them we continue counting in another diagonal so that the statistical accuracy can be brought to a near identical level (0.95 confidence limit expressed as percentage of count: $\pm 40-20\%$). We carry out this counting with respect to about 5—20 species in a sample. For the large-bodied rare species, which, however, constitute the majority of the biomass, as for example *Ceratium* the species on the whole bottom of the chamber are counted. This is the UTHERMÖHL's (1958) elastic chamber method.

The species which had not come to the eye during the quantitntive work, but were found at the qualitative analysis, were marked with cross in the Table (HAJDU, 1974). When calculating the index these crosses were uniformly changed into one. In the interests of the calculation technique described above, the index had to be calculated by using a very high total number of algae (in an extreme case 508 000) brought together in a common unit of volume, that is, in one milliliter. Multiplying upwards is necessary to determine the proportion of the algae related to each other in a common unit of volume. This common volume must be the smallest possible so that the numbers should not be too high, therefore it is reasonable to name it as smallest common volume. Thus it is better if the smallest common volume corresponds to the largest actually counted volume of the chamber, instead of the one liter which is usual in the case of quantitative works (for example 2 ml if the-hole bottom slide is wholly counted). The data of the infraspecific taxa were interpreted as separate sources of information, they were not taken together with the data of the species; it is anyhow infrequent that the species occurs together with its variety or form.

The basic data are given in individual/milliliter units on the basis of the samples taken from the two fishponds monthly. From this and from the average volume of the individual algae, we calculated the total volume of the species as well. The diversity results calculated on the basis of the volume data will be published in my next paper. According to FOGG (1975), the production shows the best correlation with the cell surface, therefore it would have been justified to calculate the cell surface, too. However, while the volume can be well measured by means of plastiline models, in the case of the surface a kind of estimation has acquired a much greater role, therefore it was disregarded.

When counting the diversity, we used the logarithm of base two, therefore the value of H'' falling to one species is to be understood in bit individual.$^{-1}$ *

Since no definitely crystallized standpoint has as yet been reached in the literature in respect of the index to be used for the estimation of the structure dynamism of the algal associations, we composed a computer programme by means of which all parameters respectively statistics, judged as important on the basis of the preliminary orientation, can be calculated (see below numbered from 1 to 20). A few of these parameters will probably be superfluous and can be omitted from further examinations. The equations enumerated below are partly taken from the work of PEET (1974) and of PIELOU (1975), and partly the result of my own considerations.

Symbols: H' and H'' are the SHANNON diversity, $\hat{p}_i = \frac{n_i}{N}$, where $\frac{n_i}{N}$ is the relative frequency of the i-th species in the sample; s is the number of species per sample; $\widehat{\text{var}\,[H]}$ is the variancy of the SHANNON measure of diversity; H is the BRILLOUIN measure of diversity computed by STIRLING approximation accounts to equation (20); R_1, R_2, R_3, R_4 are the redundancies calculated with various accuracies; J_1, J_2, J_3, J_4 are the equitabilities calculated with various accuracies; M is MARGALEF's index of species richness; ε is the LLOYD-GHELARDI measure of

* Conversion modules: $H''_{(2)} \times 0.3010299957 = H''_{(10)}$ decit/ind., $H''_{(2)} \times 0.6931471806 = H''_{(e)}$ nit/ind., $H''_{(10)} \times 3.321928095 = H''_{(2)}$ bit/ind., $H''_{(e)} \times 1.442795041 = H''_{(2)}$ bit/ind.

equitability (LLOYD-GHELARDI, 1964); d is an index of dominancy, the ratio of the maximally represented species in the sample (SIMPSON, 1949).

$$H' = -\sum_{i=1}^{s} p_i \log_2 p_i \; ; \qquad H'' = -\sum_{i=1}^{s} \frac{n_i}{N} \log_2 \frac{n_i}{N} \tag{1}$$

$$\widehat{\mathrm{var}\,[H'']} = \frac{\sum_{i=1}^{s} \frac{n_i}{N} \log_2^2 \frac{n_i}{N} - \left(\sum_{i=1}^{s} \frac{n_i}{N} \log_2 \frac{n_i}{N}\right)^2}{N} + \frac{s-1}{2N^2} \tag{2}$$

$$H = \frac{1}{N} \log_2 \frac{N!}{n_1!\, n_2! \ldots n_s!} = \frac{1}{N}\left[(\log_2 N!) - \sum_{i=1}^{s} \log_2 n_i\right] \approx$$
$$\approx -\sum_{i=1}^{s} \frac{n_i}{N} \log_2 \frac{n_i}{N} + \frac{1}{2N}\left[-\sum_{i=1}^{s} \log_2 n_i \,(s-1) \log_2 (2\pi) + \log_2 N\right] \tag{3}$$

$$R_1 = \frac{H''\max_1 - H''}{H''\max_1} \tag{4}$$

$$R_2 = \frac{H''\max_1 - H''}{H''\max_1 - H\min_2} \tag{5}$$

$$R_3 = \frac{H''\max_2 - H}{H''\max_2} \tag{6}$$

$$R_4 = \frac{H''\max_2 - H}{H''\max_2 - H\min_3} \tag{7}$$

$$H''\max_1 = \log_2 s \tag{8}$$

$$H\max_2 = \frac{1}{N}\left[\log_2 N! - s \log_2 \left(\frac{N}{s}\right)!\right] \tag{9}$$

$$H''\min_1 = 0 \tag{10}$$

$$H\min_2 = \frac{1}{N}\left\{\log_2 N! - \log_2 [N - (s-1)]!\right\} \tag{11}$$

$$H\min_3 = \frac{1}{2N}\left[\log_2 N + 2N \log_2 N - \log_2 (N+1-s) - \right.$$
$$\left. - 2(N+1-s)\log_2 (N+1-s) - (1-s)\log_2 2\pi\right] \tag{12}$$

$$J_1 = 1 - R_1 = \frac{H''}{H''\max_1} \tag{13}$$

$$J_2 = 1 - R_2 \tag{14}$$

$$J_3 = 1 - R_3 \tag{15}$$

$$J_4 = 1 - R_4 \tag{16}$$

$$M = \frac{s-1}{\ln N} \tag{17}$$

$$\varepsilon = \frac{s'}{s} \tag{18}$$

$$d = (p_i)\max = \frac{n_{\max}}{N} \tag{19}$$

$$\log_2 N! = \log_2 \sqrt{2\pi} + \log_2 \sqrt{N} + N \log_2 N - N \tag{20}$$

Computation by a Videoton 1010 BM computer by means of ASA FORTRAN programme (available on request).

Results

Of 108 set of data, 14 parameters were calculated. In the first part of the series of papers, we give here the most important data calculated on the basis of the number of algal individuals of the species (Table 1). Later we shall describe also the changes of these parameters at the level of genus and division as well as the values calculated on the basis of the volume. Owing to lack of space, a few of the less marked parameters have been left out of the Table, but in the discussion we touch the conclusions that can be drawn on their basis.

Table 1

Yearly change of the main parameters and statistics in the two fishponds examined

Month	N 1000 i./l.	s	H'' bit/i.	$\widehat{[H'']}$ var	J_1	H	$\frac{s-1}{\ln N}$	d %	ε
Fertilized, more eutroph fishpond									
J	3 602	18	2.1613	0.0017	0.51830	2.1461	2.0759	48.96	0.33
F	3 127	19	3.2329	0.0037	0.76105	3.2098	2.2366	31.47	0.74
M	7 589	21	3.1174	0.0013	0.70970	2.9251	2.2385	34.58	0.66
A	29 016	17	2.2980	0.0003	0.56220	2.2948	1.5571	58.97	0.53
M	40 592	36	4.2057	0.0005	0.81349	4.2012	3.2984	15.58	0.75
JY	349 518	72	1.7994	0.0000	0.29165	1.7990	5.5624	79.82	0.05
A	185 570	68	2.6742	0.0001	0.43929	2.6726	5.5230	56.12	0.13
S	508 734	53	2.1272	0.0000	0.37137	2.1266	3.9575	66.21	0.11
O	156 111	67	3.2066	0.0001	0.52861	3.2336	5.5192	39.80	0.19
Mean	142 651	41	2.7581	0.0009	0.55507	2.7343	3.5520	47.95	0.38
Unfertilized, less eutroph fishpond									
J	257	12	2.0294	0.0283	0.56610	1.9223	1.9823	63.42	0.41
F	10 144	16	0.7867	0.0002	0.19667	0.7825	1.6261	84.35	0.25
M	5 250	18	2.9472	0.0018	0.70676	2.9338	1.9846	29.68	0.62
A	4 684	30	4.3587	0.0040	0.88828	4.3321	3.4311	9.63	1.1
M	39 068	44	4.6963	0.0006	0.86022	4.6907	4.0669	9.52	0.86
JY	24 061	46	3.4889	0.0006	0.63164	3.4824	4.4606	25.51	0.35
A	12 442	61	4.4589	0.0020	0.75183	4.4549	6.3636	15.82	0.57
S	78 207	53	4.0006	0.0002	0.69843	3.9974	4.6152	21.17	0.43
O	125 048	39	2.7378	0.0001	0.51799	2.7362	3.2379	48.24	0.23
Mean	33 240	35	3.2783	0.0042	0.64644	3.2591	3.5298	34.15	0.53

In column-diagramme No. 1, a somewhat more illustrative way of demonstration is introduced than the earlier ones: the empty part of the column indicates the mathematical maximum of diversity, while the black part indicates the actual value. Complementarily to this, in diagrammes Nos 2 and 3 the changes in the two components of diversity, viz. species number and evenness as a function of time are indicated. The linear broken line in the diagrammes denotes the yearly average of the parameter illustrated on the basis of nine samples.
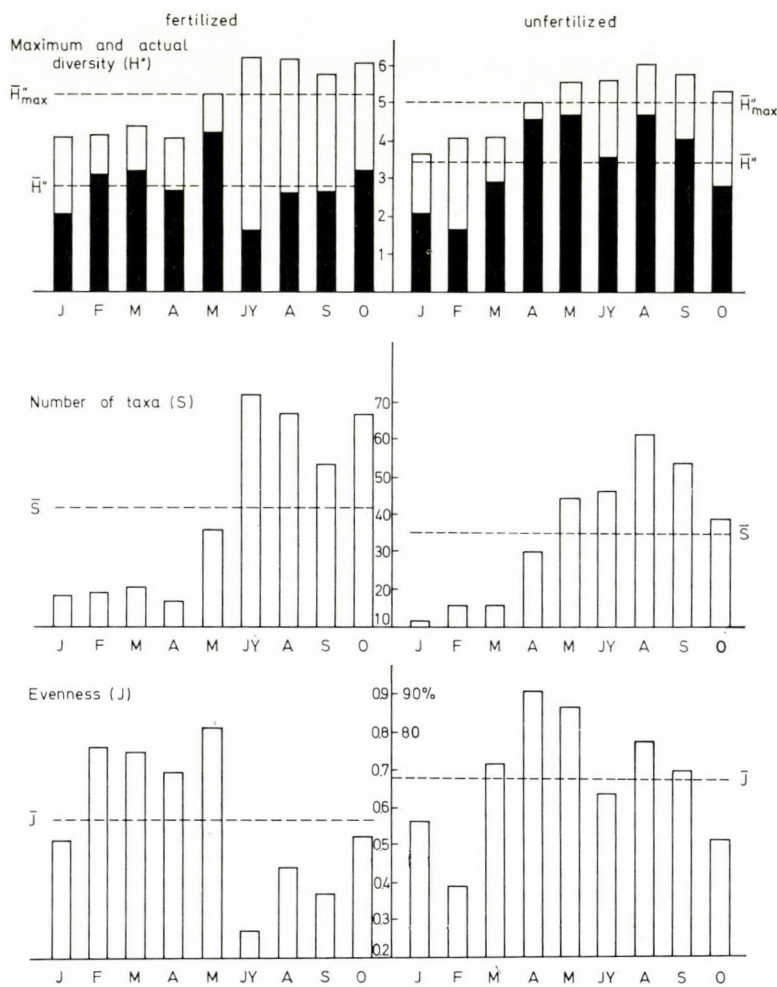
Fig. 1. Yearly course of the *Shannon*-diversity (H'') and its maximum ($\log_2 s$) in the fishponds
Fig. 2. The monthly species number (s) in the fishponds
Fig. 3. Yearly change of the evenness (J) in the fishponds

Table 2

The values of all parameters computed. Note the minor differences between H" and H, and those between R and J values

$H"$	$= 4.2057$	var $H"$	$= 0.0005$
H	$= 4.2012$	M	$= 3.2984$
R_1	$= 0.18651$	J_1	$= 0.81349$
R_2	$= 0.18703$	J_2	$= 0.81297$
R_3	$= 0.18652$	J_3	$= 0.81348$
R_4	$= 0.18708$	J_4	$= 0.81292$
d	$= 15.58\%$	ε	$= 0.75$

On a randomly chosen sample (fertilized fishpond, in May) we present all the fourteen statistics (Table 2), when $s = 36$, $N = 40\,592$ thousand ind.liter^{-1}.

Column diagramme No. 4 shows the changes in the total number of algae during the year, while diagramme No. 5 the dominance calculated on the basis of equation No. 19.

After HUTCHESON (1970) we made a t-test on the basis of var $H"$; all $H"$ differed from one another at a very high degree of freedom.
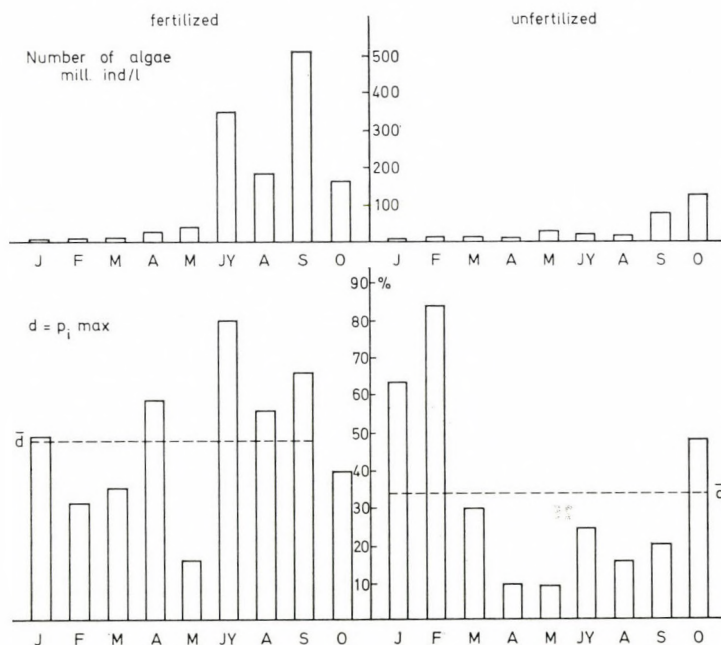
Fig. 4. The number of algae (N) in the different months in the fishponds
Fig. 5. The change of the index of dominancy (d) in the fishponds

Discussion

The average of diversity (if not otherwise indicated, by diversity we always mean H'') is lower in the more eutrophic pond than in the less eutrophic one, even though the average of the possible maximum ($\log_2 s$) is, owing to the greater species number, even somewhat higher in the eutrophic pond. In other words: the actual diversity at the average approaches the possible one better in the less eutrophic pond.

Considering the various diversity values, two minimum values occur during the year: one in winter and the other in the middle of summer. In the evaluation we must pay attention to the diagrammes of evenness and of species number; in the winter period which is poor in sunshine, the evenness is also low, the actual H'' is hardly more than the half of the possible value. Improving conditions make the increase in evenness much sooner possible than they do in relation to species richness. Since evenness rises quickly and stays at a high level even subsequently, in this period a further increase of H'' depends on the species number. The same dependence on the species number is characteristic of the autumn and winter periods as well, but only with an opposite sign, that is, the decrease of the species number has a decisive effect on the changes in H''. In the middle of summer, the situation is different, the species number hardly changes, but evenness decreases considerably, that is, a few of the species are extremely dominant. The decrease in evenness is much more pronounced in the more eutrophic pond.

On the basis of the preceding analysis it appears that the number of species determines diversity in a considerable part of the year, and this determination predominates to a smaller extent in the more eutrophic water; in the period of a great number of algae, a small evenness is the decisive forming
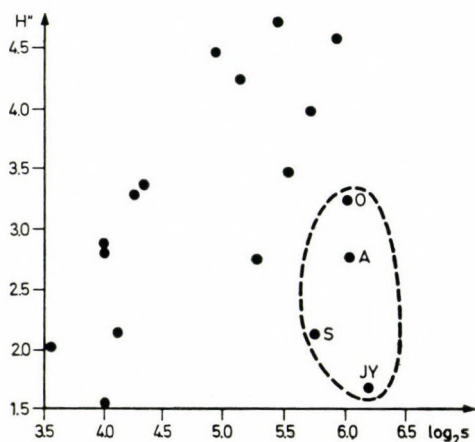
Fig. 6. Correlation diagram between H'' and H

component. To prove this, we calculated from the data of the two fishponds a linear correlation between the values of H'' and H_{max_1}. The latter is $\log_2 s$, thus it depends only on the species number. Incidentally, it should be mentioned that as a matter of fact correlations should be searched for only between measured data of known distribution. Correlations between calculated parameters — especially if they also have a common member — is not interpreted. It is apparent in the correlation diagramme (Fig. 6) that if the enclosed points are left out of consideration then a good correlation can be expected. Such a stratagem is allowable in the case when there is a biological reason for leaving out something from our consideration. In this case, the requirement is completely fulfilled, since the four points fall indeed to the summer period of the fertilized pond, when evenness is low (the letters by the side of the points are the initials of the months).

From the total 18 data $r = +0.3208$ N.S. $p > 10\%$ Leaving out July — October, $r = +0{,}7746$ $p < 0{,}1\%$ $n = 14$, $Y_{(H)} = X_{(\log_2 s)} - 1{,}48$.

Only July — October $r = +0.0595$; there is no assessible correlation, for the whole year between J and H'', $r = +0.2636$ N.S., $Y_{(H)} = 2.11 + 1.46\,X_{(J)}$.

It clearly appears that diversity has a section depending on s, and another one depending on J, and this J-dependence (that is, the low J decreases diversity strongly) is more pronounced at the time of the greater number of algal individuals. The J-dependence here indicates the more eutrophic character, it appears at an of algal density about 100 million individual/liter. It is worthy of attention that HULBURT (1970) also noticed the appearance of the nutrient competition at a similar order of magnitude in the number of algal individuals; it was in this period that the spheres lacking nutrient around the algae intercepted with one another. We attempted to determine in the ponds examined when is it that the J-value is critical from the viewpoint of forming the diversity index. $J = 0.5$ appears to be such a limit value, but only when the number of the species is at the same time great. In the fertilized fishpond it is critical from July to October, it is not critical in the fertilized pond in January, in the unfertilized one in January, February and October because in the latter cases a low s accompanies the low J. A more unambiguous border line can be drawn on the basis of ε, since here the values below 0.2 indicate without exception the critical unequitability. KIRCHER (1972) observed in birds similar s-dependent and J-dependent periods in diversity; J dependence was characteristic of the unfavourable period even there.

I tried to detect what kind of environmental factor can be responsible for the sharp separation of the two periods. At the time of the J-dependence the most characteristic feature in the eutrophic pond, from the point of view of the algae, is that the unsatisfied nutrient demand surpasses by several hundreds of thousand times the nutrient supply, for example, in phosphorus.

Although the a smaller extent, a similar shortage occurs in other important nutrient elements as well (FOGG, 1975). Unfortunately, I could not count a correlation between the concentration of the nutrient and the evenness, because I had not enough data from this period nor possibilities to measure the nutrient-content data of such a great sensitiveness. In this case theoretical considerations must substitute proof. The nutrient shortage in summer is an unquestionable fact. Several algae are able to store phosphorus in quantities that extend far beyond their need. These, at the time of shortage in phosphorus, are in a more advantageous position than their fellow algae, while such an advantage leads invariably to the decrease in evenness. FUHS (1969), for example, experienced that the reproduction of the two diatoms examined was more decisively influenced by the quantity of phosphorus which had already been bound in the cell than by the one which had been solved in water. In the four summer months of low evenness, the proportion of the blue-green algae increased, and in August even water bloom appeared. The blue-green algae may secrete materials into the water which inhibit the reproduction of the other algae (BOYD, 1973; MURPHY et al., 1976). This inhibition has also an effect towards the decrease in J. Concerning the shortage in nutrient during the critical four months, there is an indirect evidence. From the basic data (HAJDU, 1974), a Bravais-type linear correlation is calculated between the total number of bacteria counted on the membrane filter and the total number of algae. The correlation is positive for the unfertilized pond: $r = +0.603$ $p < 5\%$, October left out: $r = +0.843$ $p < 1\%$; it is, on the other hand, no for the fertilized pond: $r = -0.016$ $n = 9$ N.S. If in the fertilized pond the time interval is narrowed towards the greater algal number, then between May and October the correlation is already closer, but still not acceptable, $r = -0.831$ $p < 10\%$ $n = 5$, while in the critical summer months, between July and September, the correlation is even closer, $r = -0.999$ $p < 5\%$ $n = 3$. The greater mass of the algae inhibits the bacteria in the competition for the nutrient, that is why the increasing negative correlation occurs (cf. RHEE, 1971, FITZGERALD, 1969 etc.).

The graph of species richness rises until the summer period, then it decreases and automatically offers the hypothesis that the species number changes in proportion with the quantity of sunshine during the year. The sunshine can be characterized on the one hand by the insolation, its unit is Kkal cm^{-2} $month^{-1}$, and on the other hand by the duration of sunshine, its unit is hour $month^{-1}$. For the correlation calculation I used the 50 years' average of the data measured by the Meteorological Institute in Budapest. Insolation and species number show close correlation: $r = +0.6161$ $p < 1\%$ $n = 18$. The duration of sunshine and the species number show more close correlation: $r = +0.7134$ $p < 0.1\%$ $n = 18$ $Y_{(s)} = 5.8912 + 0.1810X$. Thus it is not the intensity of sunshine but rather its duration that determines the

species richness in the ponds; the coefficient of determinations $r^2 = 0.5089$, that is, the duration of sunshine is to 50.89% the cause of the great species number in summer.

Summarily we can say that in the ponds examined the components of diversity — evenness was decisively influenced by the nutrient supply, while that of the species number by the number of the hours of sunshine. Naturally, the determination here is not direct; the factors have effect evidently by the agency of niche proliferation and decrease.

As can be seen the simpler diversity conception (diversity = species number), would not have enabled us to recognize an unfavourable effect — so important for the community — as in our case the summer nutrient shortage was — and it even would inform us in a diametrically opposed sense regarding the critical period.

From the data, we calculated the index of LLOYD-GHELARDI (1964) (see Table 1). One of the data is worthy of special mention: the April ε of the unfertilized pond is 33; dividing it by 30 produces 1.1, that is, nature showed a more even distribution in this case than it would be allowed by the maximum of the MACARTHUR model which was used. The high ε indicates a one-dimensional limitation. The yearly course of ε follows its J well, which is natural of course, because both of them reflect a ratio in relation to a maximum. ε is numerically a smaller value because here the basis of comparison is not the mathematical maximum, but a smaller one, the hypothetical natural maximum. As has been mentioned earlier, ε characterizes the critical points of evenness better than J does.

In Table 2 we presented the values determined with varying accuracy. Here the following relations of magnitude can be observed:

$$H < H''; \; J_4 < J_2 < J_3 < J_1; \; R_1 < R_3 < R_2 < R_4$$

It is noteworthy how closely H and H'' appear to each other (cf. Table 1 and 2), even though we did not know the distribution of the population here but estimated it by means of the sample. The BRILLOUIN index can be considered a very sensitive one (PIELOU, 1975) to the identical sample size (N); we worked with varying sample size and this does not even appear in the differences H and H''. The various J and R values did not differ considerably from each other either, despite the fact that they were calculated with varying accuracies. All these can probably be attributed to the fact that the basic data were very high and therefore even the inaccurate STIRLING formula could give a satisfactory approximation. We must, however, be aware of the fact that this is only a security of appearance, because we have worked not with the actually counted data but with the much greater values resulting from multiplication up to milliliter.

If J is given, then it is superfluous to give also redundancy, because they complement each other to one, and thus one can be calculated from the other. In environmental protection studies, applying R instead of J is to a certain extent more expressive, since this changes in a direct proportion with pollution and detriment. On the other hand, J is an optimistic parameter; it increases in an environment which is optimal for the majority of organisms. In the interpretation of PATTEN (1962), succession is a phenomenon in which the planktonic algal community develop from the low R towards the higher one, that is, from the high J towards the low one. If we accept this interpretation, then we can observe two courses of succession in the ponds; one lasts up to July, the other begins at this time. The extension of the concept of succession in this way is, however, not entirely accepted. In the examinations by EMLEN (1973), H'' decreased towards the end of succession, while in opposition to this IGNATIDES (1969) observed that diversity was in increase during the succession; ODUM (1969) also considers this rising tendency as generally valid. FOTT (1975) draws the line of succession stages at the main transformations of the community, thus it appears now at low diversity, then at a high one. In the water, succession always tends toward the terrestrial association (periphyton, macrophyta); it is doubtful whether there is indeed a succession, also within the plankton association, or if it is merely a periodicity without any tendency.

In Table 1 and in Fig. 5, the index of dominance is also indicated. In the interests of clarity, p_i max is given in percentage. This does not tell us more than the former parameters did; it reminds us mostly of the trend of R, but the essential points are occasionally even more conspicuous (fertilized pond, July; unfertilized pond, April and May).

The correlation between the MARGALEF index (M) and H'' is close; $r = +0.5942$ $n = 18$ $p < 1\%_0$. The MARGALEF index can be calculated very easily and, as is clear from this close correlation, it reflects the changes faithfully. It has, however, other deficiencies, as for example in the lack of any theoretical background, no auxiliary parameter of evenness can be counted to it, etc. It is by no means suitable for the substitution of the SHANNON index, but for a quick orientation it can be used well.

It is a definitive characteristic of the diversity index that it indicates the conditions deviating from the permanent average: the greater the deviation from this long-term average: the more considerable the decrease in the index (possibly, its increase). If the question is whether trophy can be indicated by the diversity index then the answer to this question is to be found primarily in an eutrophic water. The two fishponds examined gave a good example of the extent to which diversity decreases at the time of a higher number of algal individuals. In an oligotrophic water, presumably other factors are decisive in the formation of the index, and not eutrophy. Such an oligo-

trophic lake does not exist in this country, so I could not extend my examinations into this direction. The data examined in the present paper also indicate that correlation between H'' and the number of algal individuals is only possible at the time when the number is great, for there is no correlation between H'' and N when related to the whole year ($r = 0.3037$ N.S., $n = 18$).

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STUDY OF ASSIMILATION TYPES IN SPECIES OF A SAND STEPPE COMMUNITY

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Assimilation type of 30 species of the "Kis Tece" sand steppe community (*Festucetum vaginatae, F. wagneri*) near Vácrátót was studied. Of the 30 observed species grown in a steppe area with warm and dry microclimate four appeared to be C_4, and seven of the C_3 assimilation type, while seven proved to be $C_3 — C_4$, that is, of the intermediary type. Twelve species could not be evaluated by the method used owing to its high acidity.

Introduction

In an ecosystem, the stream of energy can, from any given point, be traced back in most cases to the primary energy fixation process of the green plants. Photosynthesis, the carbonic assimilation, is the most important problem of the entire biosphere. Since the photosynthetic carbon-assimilation the only was of formation or organic carbonic compounds from the inorganic carbonic compound carbon dioxide, therefore, in respect to production of organic substances, its efficiency distribution in time and space are equally important.

In the last ten years, the research of processes of CO_2 assimilation led to the discovery of a new mechanism (KORTSCHAK et al., 1965, HATCH and SLACK, 1970). It was proved that the primary CO_2-fixation of some plants did not take place in the Calvin-cycle (C_3 type) but in a so-called C_4 dicarboxilic acid cycle. Several characteristics of photosynthesis of the C_4 type were different from those of the C_3 type. These characteristics are summarized in Table 1 (SMITH, 1976).

It is in the selective advantage of such a type of CO_2 assimilation that the source of evolution of photosynthesis should be searched for. Results of enzyme studies led to the recognition that RuDP-carboxylase could function as an oxigenase in the presence of high oxygen and low carbon dioxide concentration and that the efficiency of photosynthesis was strongly reduced by the formation of photosphoglycolate (BOWES and OGREN, 1972).

In plants of the C_4 assimilation type, having a CO_2 reduction pathway via the CALVIN-cycle in the chloroplasts of the bundle sheath parenchyma cells, RuDP-carboxylase can operate at a lower oxygen concentration and the

competition between O_2 and CO_2 scarcely follows. Besides, the efficiency of the C_4 dicarboxylic acid cycle operating in the mesophyll cells in increased by the higher affinity of PEP-carboxylase to CO_2 than that of the other CO_2 fixing enzyme (Table 1). This phenomenon is especially important in the ecological conditions of reduced water supply and a limited gas exchange owing to the closed stomata.

Table 1

Some distinctive parameters of C_3 and C_4 types of photosynthesis

Parameters	C_3	C_4
Primary CO_2 fixing enzyme	RuDPC	PEPC
Green bundle sheath parenchyma	absent	present
Requirement of CO_2 concentration	30–150 ppm	10 ppm
Light saturation	40 klux	complete sunlight, intensity
Optimum temperature (for CO_2 fixation)	15–20 °C	33–35 °C
Photorespiration	active	low

On the basis of these facts it was established that algae, mosses, ferns, gymnosperms had exclusively the C_3 type of photosynthesis, as also the majority of Angiosperms. Species of the C_4 assimilation type can be found in some 13 families of flowering plants (SMITH, 1976, DOWTON, 1975). Probably the absence of a close relationship among these families suggest a polyphyletic origin of the C_4 type of photosynthesis and also an adaptation to the warm and arid climate (MOORE, 1974).

On the basis of biochemical and anatomical investigations, species with free cross-pollination and of different CO_2 assimilation types were found in the above-mentioned families. For example, the presence of specific PEP-carboxylase isoenzymes were demonstrated in the parent and hybrid plants. Isoenzymes of the parent plants were different, but in their hybrids isoenzymes of both parents could be detected (HATCH et al., 1972). These results also suggested the absence of a clear-cut boundary between the two assimilation types, and thus the occurrence of intermediary forms.

Biochemical or anatomical characteristics of leaves of the intermediary forms can be either of the C_3 or C_4 type (KENNEDY and LEATSCH, 1974).

The assimilation type of a plant can be established by determination of one of the most typical parameters, the ratio of carboxylating enzymes (RuDPC and PEPC). Determination of the enzyme activities is a comparatively simple method. According to the literary data, the ratio of the RuDP-carboxylase and PEP-carboxylase activity in typical C_3 species (e.g. *Hordeum vulgare*, *Spinacia oleracea*) is about 22 and 14, respectively, while that of typical C_4 species (e.g. *Digitaria sanguinalis*, *Zea mays*) is about 0.2 and 0.6, respectively.

Species with an activity ratio between the two extreme values (about 2) are considered as intermediary forms (GOLDSTEIN et al., 1976). On the basis of this short summary it is evident that also in the case of species with an intermediary assimilation type the possibility of a selective advantage in changing environmental conditions is valid. For this reason, it is interesting to study whether there exist such species in a given phytocenosis, and also to know how environmental conditions influence the possibilities of CO_2 assimilation.

Material and aims

For the observation, an experimental area was chosen which was being investigated from several points of view. In this area, the occurrence of C_3 and C_4 plant types was studied. The grassland of the "Kis Tece" sand steppe at Vácrátót was chosen for the collection of plant samples. The vegetation consists of mosaic-like (Alternating) spots of the communities *Festucetum vaginatae danubiale* and *Festucetum wagneri.* This area is undisturbed and there have been no agricultural activity there since 10—15 years. It is probable that in earlier times some parts of the area had been cultivated occasionally. The succession has now advanced so far that there is no physiognomical and cenological differences between the formerly cultivated and the original, undisturbed areas. In addition to the two constituent *Festuca* species of the community, *Fumana* and *Medicago* are locally dominant, while smaller areas covered by the moss-lichen synusium are the most conspicuous.

The whole area is covered by a quicksand — like Pleistocene deposit of the Danube. Beneath spots of the dominant *Festuca wagneri* and *Poa angustifolia*, a thick layer of about 15—20 cm humus had formed.

The above mentioned communities have a double vegetation period: in spring and in autumn. They have also two rest periods during the summer aridity and in winter. The area studied is characterized by extreme warming up, sometimes moderated by wind. The level of the subsoil water is more than 5 m, and thus important only for plants (e.g. *Fumana, Eryngium*) with long roots. This subsoil water level cannot be reached by *Gramineae* which are wholly seared by the middle of summer. The stocks surviving the drought revive and they commence an increased vegetative development by the effects of the autumnal rains.

In our experimental area, the occurrence of species of the C_4 type was expected as a result of the microclimate which is frequently similar to semi desert circumstances. To detection of these plants is important for the research work done in the Department of Zoology, University of Agriculture (Gödöllő), and for the Department of Plant ecology, Botanical Research Institute, HAS (Vácrátót), because the nutrition biology of the fauna of the area is also studied. Literary data suggest that species of the C_4 type, as food sources, are of lower quality than the C_3 type plants for the herbivorous animals. Most of the observations were carried out with insects feeding mainly on species of the C_3 type though no preference was found. Distinction between the C_3 and C_4 type plants may be significant, because of the assumed effects of interspecific competition. According to some hypotheses, such a selective plant consumption has an important ecological role. It may occur that an insect is apparently hungry, though it has plenty of the C_4 plant types. The process of decomposition is also different in the two assimilation types, because the breakdown of C_4 species is slower (CASWELL et al., 1973).

Detailed information on ecological studies and literature of the model area at Vácrátót can be found in the paper of FEKETE—PRÉCSÉNYI—MOLNÁR—MELKÓ (1977).

The plant material for the study was collected on 2 and 13 October, 1976. and it was processed immediately.

Experimental methods and results

On the basis of the above mentioned data it is evident that the ratio of activities of the two carboxylating enzymes can be used to distinguish the two assimilation types of plants. For this reason, first, the RuDP- and PEP-

carboxylase activity of species collected from the given communities was measured. From the weighted samples of green plant parts, the enzymes were extracted by BJÖRKHAM's method (1968). The enzyme activities were determined by measuring the ^{14}C incorporation in presence of D-ribulose-1,5-diphosphate and phospoenolepyruvate, so that $H^{14}CO_3^-$ was added, as another substrate, to the system (BJÖRKMAN and GAUHL, 1969, NAGY et al., 1973). In species with leaves of an acidic character, the activity of the two enzymes cannot be determined by this method. Results of the experiments are presented in the following table (Table 2).

Table 2

The enzyme activities and assimilation types of the species studied

Species	PEP-carboxylase / μ mole CO_2/g/hr	RuDP-carboxylase / PEP-carboxylase	Assimilation type
Carex praecox	0.14	41.1	C_3
Achillea ochroleuca	0.38	9.1	C_3
Andropogon ischaemum	1.87	0.1	C_4
Carex liparicarpos	0.54	31.5	C_3
Carex praecox	8.05	1.5	C_3—C_4
Carex stenophylla	5.76	2.5	C_3—C_4
Centaurea arenaria	1.34	13.0	C_3
Cynodon dactylon	5.11	1.4	C_3—C_4
Cytisus ratisbonensis	0.60	14.7	C_3
Digitaria sanguinalis	1.89	0.4	C_4
Festuca vaginata	0.36	2.9	C_3—C_4
Festuca wagneri	2.17	4.8	C_3—C_4
Plantago indica	0.05	167.3	C_3
Poa angustifolia	3.29	2.9	C_3—C_4
Poa bulbosa	2.40	1.6	C_3—C_4
Silene otites	1.50	0.1	C_4
Scleranthus annuus	12.03	0.6	C_4
Syntrichia ruralis	0.06	75.3	C_3

Owing to an acidic character of the leaves, the method could not be used in the following species: *Cladonia foliacea*, *C. furcata*, *Erodium cicutarium*, *Euphorbia seguieriana*, *Eragrostis pooides*, *Fumana procumbens*, *Holoschoenus romanus*, *Medicago minima*, *Polygonum arenarium*, *Potentilla arenaria*, *P. argentea*, *Thymus serpyllum*.

The data clearly show that, in addition to the species excluded by the inapplicability of the method, only four out of the 18 species observed proved to be of the typical C_4 assimilation type.

It is remarkable that the PEP-carboxylase activity of the species considered as intermediate by the ratios given in literature surpasses that of the C_3 types (except *Festuca vaginata*), and that they are near the C_4 type species.

They are probably able to reduce CO_2 by both pathways, and in these plants one of the two cycles operates dominantly depending on the environmental conditions. On the basis of repeated measurement made during the spring vegetation period, further conclusions are expected.

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ELECTRONMICROSCOPICAL EXAMINATIONS OF FOSSIL ANGIOSPERMATOPHYTA POLLEN GRAINS FROM THE PALEOCENE AND THE MIDDLE EOCENE

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Paleocene and Eocene fossil *Angiospermatophyta* pollen grains were brought under SEM examinations. The results showed characteristics not detectable by the earlier light-microscopical method. The present work also substantiates the significance of the SEM method in the knowledge of pollen grains.

I. Introduction

The aim of the present work was the assessment of the scanning electronmicroscopical results related to some *Angiospermatophyta* pollen grains of stratigraphical, facies, ecological and pollen-morphological importance in comparison with the earlier light-microscopical descriptions.

II. Material and method

In accordance with the aim of the paper, the following pollen grains were examined:

1. Stephanoporopollenites hexaradiatus (Thg. 1940) Th. & Pf. 1953 subfsp. *semitribinae* W. Kr. 1961. Locality: Menat, France, Paleocene, Thanetian formation II.

2. Echimorphomonocolpites echinatus (Muller 1968) L. Rákosi 1973.
Locality: Oroszlány, Hungary, Middle Eocene, lignit deposit sediment.

3. Kopekipollenites magnus (L. Rákosi 1973) n. comb. Locality and geological age are identical with those of the preceding.

The pollen grains selected while dry were put on polyvynilchlorid adhesives (cf. LEFFINGWELL & HODGKIN, 1971). Shading was carried out by gold, the pictures were taken in the Electronmicroscopic Laboratory, Department of General Zoology, ELTE by an SM-50A Jeol type apparatus. The author is indebted to dr. J. KOVÁCS, senior lecturer, for his assistance given in the laboratory examinations.

III. Results

1. Stephanoporopollenites hexaradiatus (Thg. 1940) Th. & Pf. 1953 subfsp. *semitribinae* W. Kr. 1961 (Plate I, 1—4).

The work of GÓCZÁN, GROOT, KRUTZSCH & PACLTOVÁ (1967) is significant with respect to the light-microscopic taxonomy of the species. The study of

KEDVES, HEGEDÜS & BOHONY (1971) may also be mentioned, concerning stratigraphy. By the form-species, the *Normapolles* or "its transitional region" of the Euro-Asian continent, the Paleocene age can be determined with certainty. A finer taxonomy of the species makes further distinctions possible. It is interesting that this form-species has not yet been known from the *Normapolles* region of the North American continent; it is probably absent from that area (cf. KEDVES & KIRÁLY, 1968).

No TEM data are so far known of this form-genus.

Pictures were taken of the pollen grains chosen for publication at various settings; change in the setting was arranged at 45—60° (see 1, 2 in Plate I). The apertures are different in the various settings. They exogerminalia are sometimes typically circular, however, apertures slightly elongated towards the poles are more general, resembling colpi. The size of the exogerminalia is around 0.5—0.7 μ. The surface ornamentation is rather varying at high magnifications (3, 4 in Plate I). Locally, semispherical formations can be observed. The most general is the rugulate ornamentation; the width of its elements is around 0.6—0.8 μ.

2. Echimorphomonocolpites echinatus (Muller 1968) L. Rákosi 1973 (1—3 in Plate II).

Owing to the facies ecological importance of the micro- and macrofossils of the genus *Nypa*, several studies discuss them. L. RÁKOSI's work (1973) summarizes the light-microscopical nomenclature of fossil pollen grains. For the time being, no TEM data are known on this pollen grain.

A number of half-pollen grains, corresponding to their light-microscopical morphology, have undergone scanning electronmicroscopic examinations. The surface ornamentation along the colpus and of the extragerminal exine are identical. The outermost ectexine layer (the tectum) is perforated. The perforations are general circular. Two types as to size can be distinguished, the width of the smaller is 0.2—0.3 μ, that of the bigger ones 0.5—0.7 μ.

After HASELDONCKX (1972), data on recent and fossil *Nypa* pollens are available. Although the detailed descriptions of the scanning results have not been published, the perforations of the tectum are observable on both the recent and the fossil materials. It should be mentioned that, on the basis of HASELDONCKX's pictures, the surface of the large spines is not entirely smooth. This characteristic cannot unambigously be stated from our own pictures.

3. Kopekipollenites magnus (L. Rákosi 1973) n. comb. (1—3 in Plate III, 1—4 in Plate IV).

Syn.: 1973, L. Rákosi — *Diporites magnus* n. fsp. 1974, Kedves — *Kopekipollenites transdanubicus* n. fgen. et fsp.

A very characteristic form in the Eocene deposits of Hungary.

Concerning the pollen grain, also TEM data are available (1—3 in Plate III).

The exine consists only of ectexine (1 in Plate III). The tectum is locally perforated (1, 2 in Plate III), its surface wavy, with smaller and larger protuberances. The morphology of the infratectal layer elements in the cross-section pictures is columnar or furcate. The character of this layer is recognizable in the tangential sections (3 in Plate III), in essence alveolar. The size and morphology of the alveoli are varying. In comparison with the two former layers, the pedium is thin, T/I/P = 2—3/2—2.5/1.

SEM results: a number of specimens have been examined, and identical results have been obtained. The pores are circular the ornamentation of the apertural surface and of the extraapertural exine is identical (1—4 in Plate IV). The tectum is locally canaliculately (0-2μ width) perforated (4 in Plate IV). The surface is rugulate, the width of the ornamental elements is 1.5—2 μ, that of the furrows is 0.1—0.15 μ.

Summary

1. The surface of *Stephanoporopollenites hexaradiatus semitribinae* is uneven, essentially rugulate; the size and morphology of the submicroscopic ornamental elements are varying.

2. The tectum of the fossil *Nypa* pollen grain is perforated as opposed to the light microscopical data.

3. The submicroscopic tectal formations of the germinal and extragerminal exines of Kopekipollenites are identical. The tectum is perforated.

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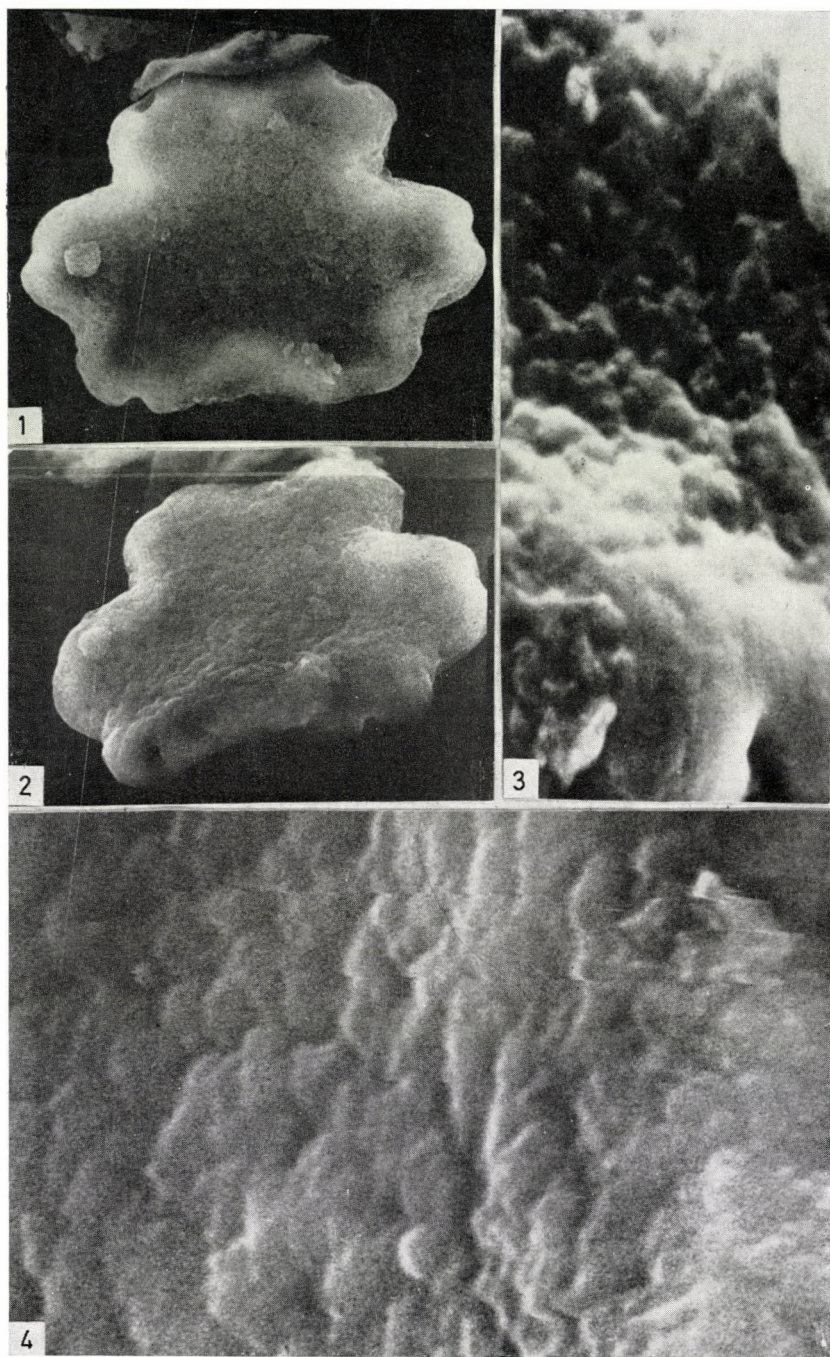
Plate I

Stephanoporopollenites hexaradiatus (Thg. 1940) Th. & Pf. 1953 subfsp. *semitribinae* W. Kr. 1961. (The pictures were taken of identical specimens) 1., 2. A total picture of the pollen grain examined in various settings ×3000; 3. The ultrasculpture of the germinal region. ×10 000; 4. The ornamentation of the extragerminal exine. ×10 000
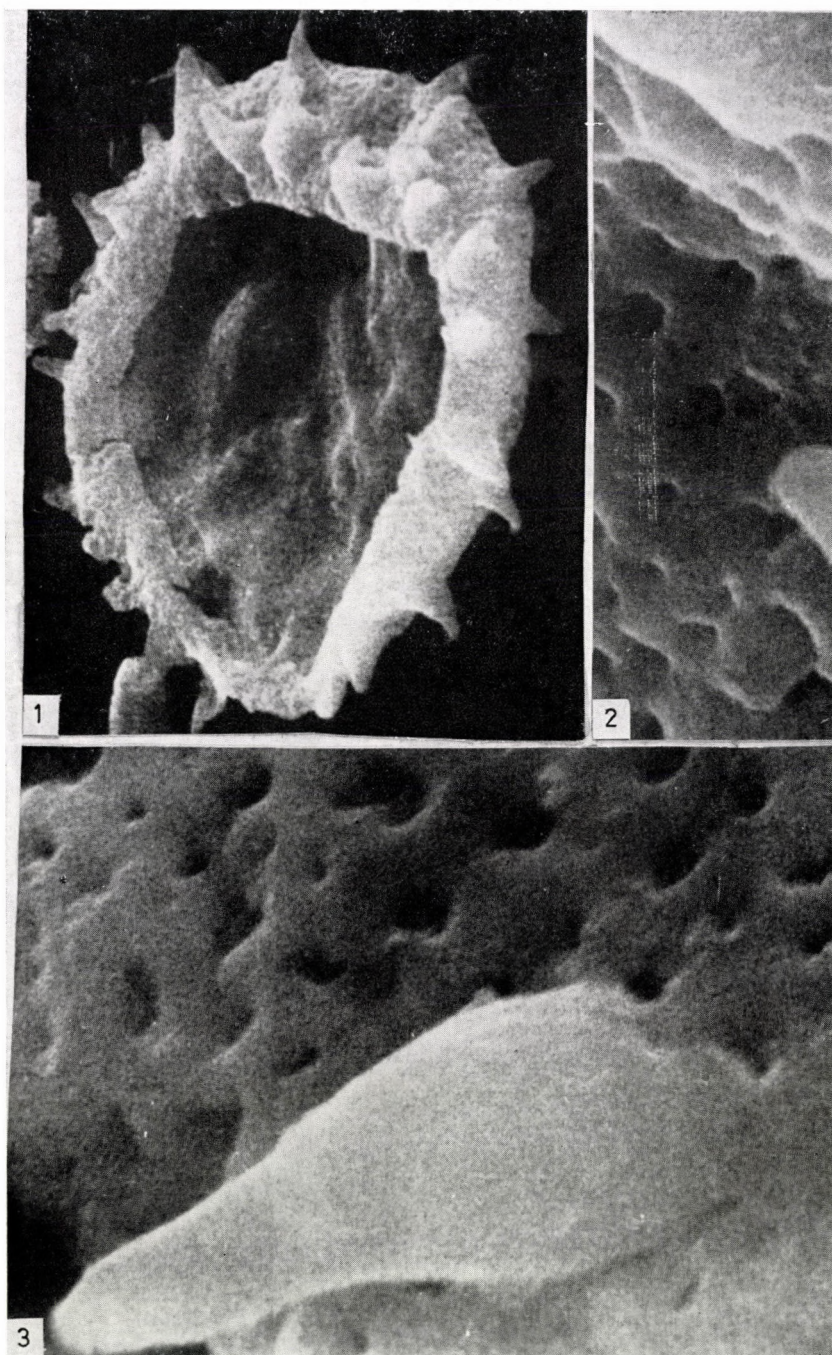
Plate II

Echimorphomonocolpites echinatus (Muller 1968) L. Rákosi 1973; 1. A total picture of a half pollen grain. ×2000; 2., 3. Details of the submicroscopic tectum. (The pictures were taken of another specimen.) ×10 000
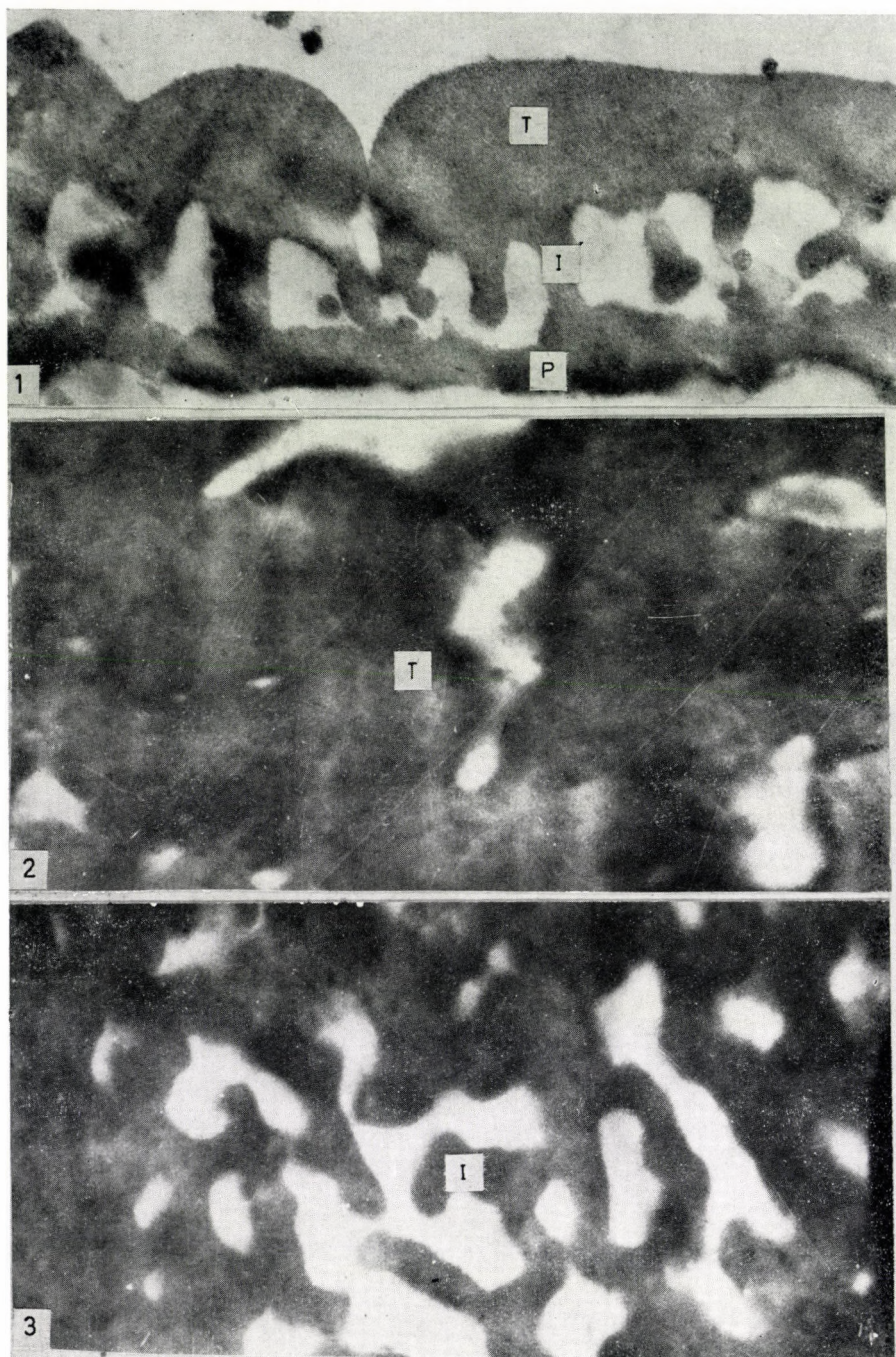
Plate III

Kopekipollenites magnus (L. Rákosi 1975) n. comb. TEM exine structure. 1. Cross-section of the extragerminal exine. ×25 000; 2. Tangential section of the tectum. ×25 000; 3. Tangential section of the infratectal layer. ×25 000; T = tectum, I = infratectal layer, P = pedium
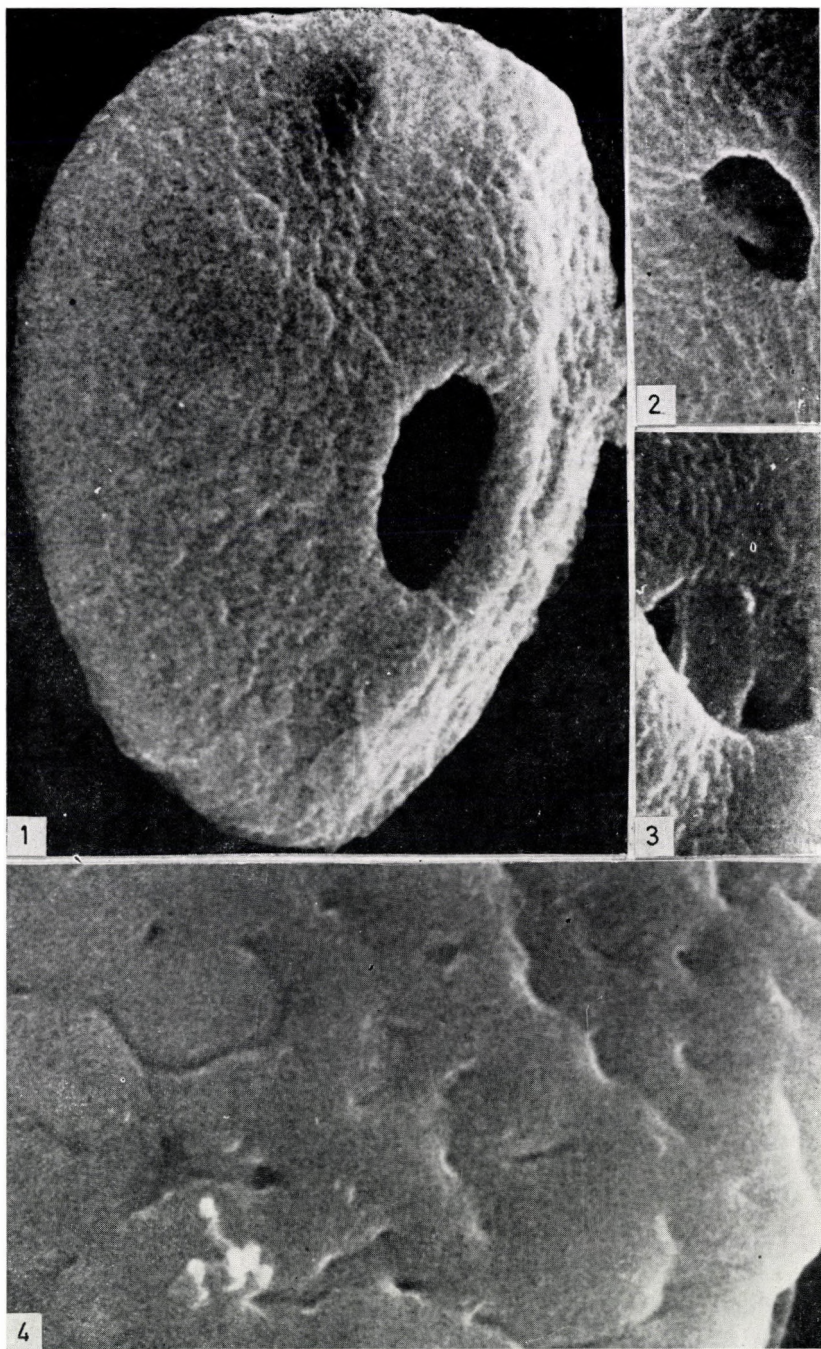
Plate IV

Kopekipollenites magnus (L. Rákosi 1973) n. comb. 1. Total picture of a pollen grain. ×2000; 2., 3. Details of the germinal region of other specimens. ×2000; 4. Detail of the ornamentation surrounding the pore (picture taken of the specimen shown in Fig. 1). ×10 000

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DER ABBAU VON WALDSTREU, DAS FREIWERDEN BIOGENER ELEMENTE UNTER LABORVERHÄLTNISSEN*

By

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Decomposition of litter, resp. the release of biogene elements of stand-building and more common tree and shrub species of a turkey oak-oak forest has been investigated under laboratory conditions.

More than 50 per cent of the mass of biogene elements has been released, dissolved from the litter in 3–4 months. The element being released most rapidly and in greatest amount is potassium. Green leaves are decomposed more rapidly than dry autumn leaves (litter).

Einführung

In Hinsicht auf die Nährstoffversorgung eines Waldökosystems ist der Gang der Nährstoff-Freisetzung von großer Wichtigkeit. Wir verstehen darunter, wie lange und in welchem Maße die auf den Boden gefallene Streu mineralisiert wird, mit welcher Geschwindigkeit und in welcher Quantität die verschiedenen biogenen Elemente freigesetzt befreit, bzw. für die Pflanzen verfügbar gemacht werden. Diese Prozesse können unter natürlichen Verhältnissen untersucht werden, in dem von mir untersuchten Ökosystem wird diese Arbeit von anderen Forschern durchgeführt (s. Tóth—Papp—Lenkey, 1975). Sie können aber auch im Laboratorium, unter künstlichen Bedingungen untersucht werden. Beide Annäherungsformen können wertvolle Daten zur Kenntnis der Gesetzmäßigkeiten der biogenen Zyklen beitragen.

Ein bestimmter Teil der Laubblätter (etwa 10 Prozent) kommt während der Vegetationsperiode (bis Mitte September) im grünen Stadium auf die Bodenoberfläche. Laut den Untersuchungen von Papp—Tóth (1973) gelangen im Sikfőkuter Eichen-Zerreichenwald bis Mitte September etwa 330 kg/ha Blätter, zu Ende der Vegetationszeit dagegen 3381 kg/ha Streu auf die Bodenfläche. Während der Vegetationszeit ändert sich die chemische Zusammensetzung der Laubblätter und demgemäß kommen die verschiedenen biogenen Elemente in veränderlichen Maßen auf den Boden.

* "Síkfőkút Project" No. 30.

Untersuchungsmethode

1. Das Probenmaterial wurde vom Nordungarischen MAB-Forschungsgebiet, vom sog. »Sikfőkút Projekt« entnommen.

2. Eine ausführliche Beschreibung des Mustergebiets s. bei P. JAKUCS (1973).

3. Die Proben wurden am 10. Oktober 1973 (Streu) und am 18. Juni 1974 (grüne Blätter) von folgenden Arten des Eichen-Zerreichenwaldes entnommen: *Acer campestre, A. tataricum, Cornus mas, Crataegus oxyacantha, Euonymus verrucosa, Ligustrum vulgare, Lonicera xylosteum, Quercus cerris, Q. petraea.*

Von den lufttrockenen Blättern wurden 25 g (in zweifacher Wiederholung) in die sog. Perkolationsröhre gesetzt (vgl. RAPP, 1976, 1971). Zu einer jeden Probe wurde zu Beginn des Abbaus und nach dem Verlauf von 30 Tagen 100 ml destilliertes Wasser gegeben, das nach einer Stunde abgesaugt wurde. Die Quantität der zu Beginn des Abbaus herausgelösten Elemente ist in den Abbildungen 1—13, am O-Punkt der horizontalen Achse angegeben.

Die mit Watte gestopften Perkolationsröhre wurden in einem Thermostat mit 28 °C für 11 (grüne Blätter), bzw. 19 (Trockenblätter, Streu) Monate aufbewahrt. Je nach Verlauf von 30 Tagen wurden die Menge der abgesaugten Lösung bestimmt und die, in der Lösung befindlichen folgenden Elemente festgestellt: Ca, K, Na, Mg, N, P, Mn, Fe, Zn.

Untersuchungsergebnisse

Zu Beginn des Experiments wurde die chemische Zusammensetzung der Blätter der einzelnen Arten bestimmt (Tabelle 1). Die chemische Zusammensetzung der Blätter zeigt eine hochgradige Übereinstimmung mit den von TÓTH—PAPP—LENKEY (1974) gemessenen Werten. In größter Menge häuft sich Ca an, es kommt zu 2—3% in den Blättern von *Acer tataricum, Lonicera xylosteum* und *Cornus mas* vor. In einer Menge von etwa 1 Prozent kommen noch in den Blättern N, und in einigen Arten (*Cornus mas, Euonymus verrucosa, Ligustrum vulgare, Lonicera xylosteum*) K vor. Eine verhältnismäßig größere Quantität von Mg ist in den Blättern von *Cornus mas, Crataegus oxyacantha, Euonymus verrucosa* und *Lonicera xylosteum* zu finden. Die grössten Mengen von den untersuchten biogenen Elementen waren in den Blättern einzelner Straucharten zu messen, wie z. B. *Cornus mas, Lonicera xylosteum, Euonymus verrucosa* und *Ligustrum vulgare.*

Gewichtsverlust während des Abbaus

Das Ausgangsgewicht (25 g) der untersuchten Baum- und Straucharten mit dem meßbaren Gewicht nach dem Abbau verglichen, konnten nach dem Verlauf von 11, bzw. 13 Monaten folgende Prozentwerte im Gewichtsverlust festgestellt werden:

Der Abbaugang der grünen Blätter und unter diesen der Gang der Dekomposition bei den Straucharten, und ihr im Laufe des Abbaus zustande gekommener Gewichtsverlust ist größer als der Verlust der trockenen Blätter. Es ist anzunehmen, daß während eines intensiveren Abbaus der N-Gehalt der Blätter eine beachtenswerte Rolle spielt, und dieser Gehalt in den grünen Blättern höher ist.

Tabelle 1

Chemische Zusammensetzung der Streu im Prozentsatz der Trockensubstanz

Laufende Nummer	Zeichnung	Pflanzennahme	Zeitpunkt der Probeentnahme	Asche	N %	P %	Ca %	Mg %	K %	Na %	Mn %	Zn %	Fe %
1.	34/74	*Acer campestre*	18. 7. 1974.	10.4	1.01	0.12	1.59	0.56	0.98	0.026	0.130	0.0058	0.021
2.	23/73	*Acer tataricum*	10. 10. 1973.	7.8	1.41	0.06	2.05	0.58	0.40	0.028	0.090	0.0077	0.0195
3.	24/73	*Acer tataricum*	10. 10. 1973.	8.2	1.55	0.06	2.00	0.53	0.45	0.026	0.136	0.0085	0.0193
4.	39/74	*Acer tataricum*	18. 7. 1974.	6.7	1.23	0.14	1.45	0.42	0.55	0.026	0.082	0.0064	0.021
5.	25/73	*Cornus mas*	10. 10. 1973.	14.1	1.31	0.14	3.41	1.01	1.15	0.027	0.009	0.0055	0.0205
6.	26/73	*Cornus mas*	10. 10. 1973.	14.1	1.31	0.13	3.15	0.93	1.02	0.026	0.009	0.0051	0.0236
7.	35/74	*Cornus mas*	18. 7. 1974.	14.3	1.41	0.18	2.42	0.80	0.87	0.028	0.020	0.0037	0.013
8.	38/74	*Crataegus oxyacantha*	18. 7. 1974.	10.6	1.05	0.11	1.80	0.81	0.55	0.028	0.012	0.0037	0.018
9.	33/74	*Euonymus verrucosa*	18. 7. 1974.	8.6	1.54	0.25	1.46	0.74	1.13	0.025	0.017	0.0089	0.019
10.	32/74	*Ligustrum vulgare*	18. 7. 1974.	7.9	1.90	0.21	0.88	0.47	1.56	0.020	0.023	0.0046	0.019
11.	31/74	*Lonicera xylosteum*	18. 7. 1974.	12.6	1.37	0.17	2.19	0.94	1.63	0.030	0.017	0.0038	0.027
12.	21/73	*Quercus cerris*	10. 10. 1973.	6.6	0.98	0.09	1.10	0.24	0.43	0.019	0.080	0.0030	0.021
13.	22/73	*Quercus cerris*	10. 10. 1973.	6.3	0.96	0.09	1.03	0.21	0.45	0.022	0.080	0.0031	0.021
14.	36/74	*Quercus cerris*	18. 7. 1974.	6.1	1.72	0.20	0.76	0.33	0.88	0.028	0.087	0.0032	0.021
15.	19/73	*Quercus petraea*	10. 10. 1973.	7.2	1.01	0.10	1.40	0.39	0.45	0.019	0.192	0.0040	0.0158
16.	20/73	*Quercus petraea*	10. 10. 1973.	7.1	0.96	0.10	1.42	0.37	0.32	0.021	0.106	0.0036	0.0165
17.	37/74	*Quercus petraea*	18. 7. 1974.	6.5	1.69	0.21	1.17	0.36	0.49	0.027	0.100	0.0017	0.010

	11 Monate grüne Blätter	13 Monate trockene Blätter
Acer campestre	68	—
A. tataricum	66	76
Cornus mas	68	70
Crataegus oxyacantha	65	—
Euonymus verrucosa	65	—
Ligustrum vulgare	66	—
Lonicera xylosteum	68	—
Quercus cerris	65	72
Q. petraea	62	78

Gang des Abbaus, Menge der freigewordenen biogenen Elemente

In den Abbildungen 1—13 haben wir die Quantität der monatlich herausgelösten biogenen Elemente in mg und den Prozentwert der einzelnen Elemente (die Menge der herausgelösten Elemente gleich 100 gesetzt) dargestellt. Bei der Übersicht der Abbildungen stellt es sich heraus, daß im Laufe des unter Laborverhältnissen vonstatten gehenden Abbaus das Freiwerden der Elemente nicht gleichmäßig ist und drei Phasen unterschieden werden können.

Bei den Blättern zahlreicher Arten erfolgt in den ersten drei Monaten des Abbaus (erste Phase) das Freiwerden von einer großen Menge verschiedener Elemente, so kann bei *Lonicera xylosteum* das Maximum der ausgelösten Elemente im ersten Monat, bei *Euonymus verrucosa* und *Ligustrum vulgare* im zweiten Monat, bei *Cornus mas* und *Acer tataricum* dagegen im zweiten und dritten Monat gemessen werden. Ein Maximum der ausgelösten Elemente kann in den ersten drei Monaten bei jenen Arten gemessen werden, in denen sich der K-Gehalt der Blätter um 1 Prozent befindet. Die Maximalwerte hängen mit dem äußerst schnellen Freiwerden von K zusammen.

Die zweite Phase des Abbaus dauert 4—5 Monate lang, in dieser Zeit verlangsamt sich das Freiwerden der biogenen Elemente. Bei einigen Arten (*Acer campestre, Cornus mas, Lonicera xylosteum, Ligustrum vulgare*) ist im 5. bis 6. Monat des Abbaus ein zweites Maximum in der Quantität der freigewordenen Elemente nachzuweisen. In der ersten und zweiten Phase werden 80—90 Prozent der gesamten Menge von biogenen Elementen frei.

Aufgrund der Quantität der freigewordenen Elemente kann der rascheste Abbau bei *Lonicera xylosteum* und *Euonymus verrucosa* wahrgenommen werden, während dieser bei den anderen untersuchten Straucharten geringfügig langsamer ist.
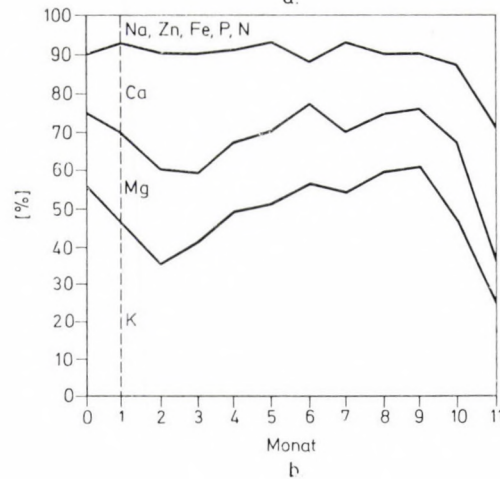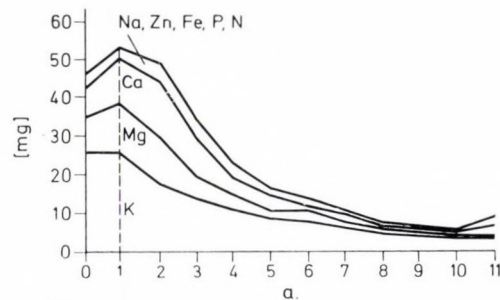
Abb. 1—13. Menge der herausgelösten Kationen in mg (a), Verteilung der Elemente im Prozentsatz der Menge von herausgelösten Kationen (b)

Abb. 1. Acer campestre *Abb. 2. Acer tataricum*
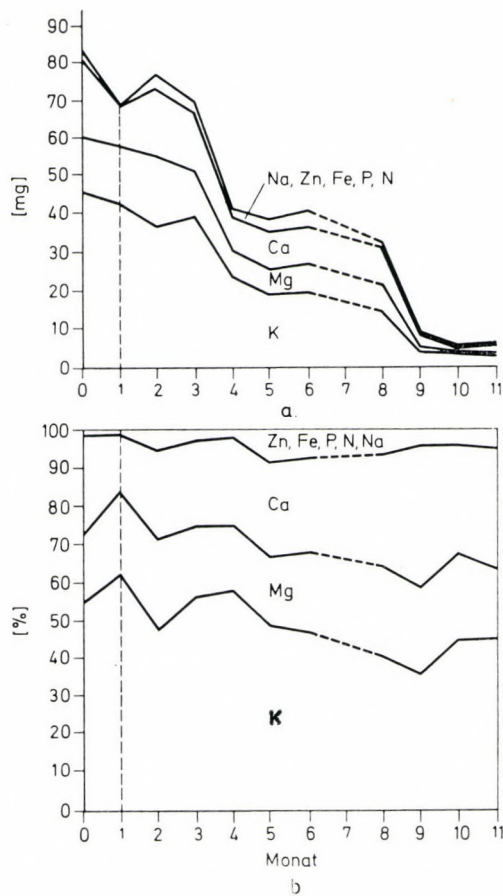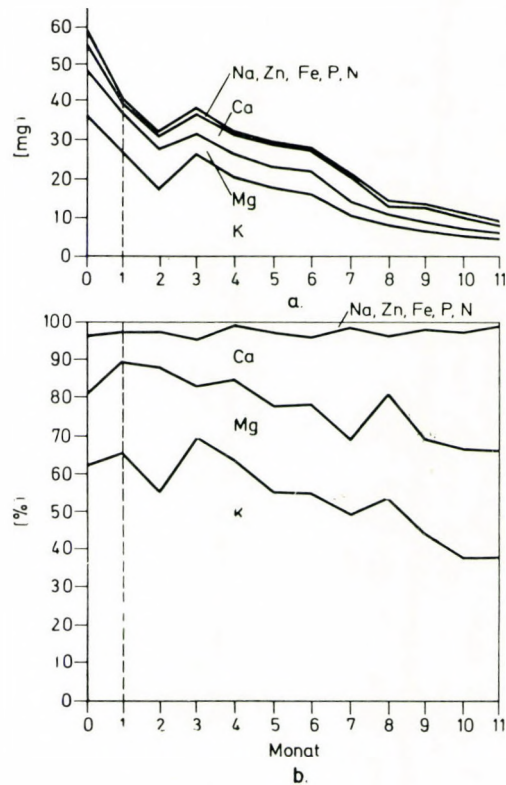
Abb. 3. Cornus mas

Abb. 4. Crataegus oxyacantha
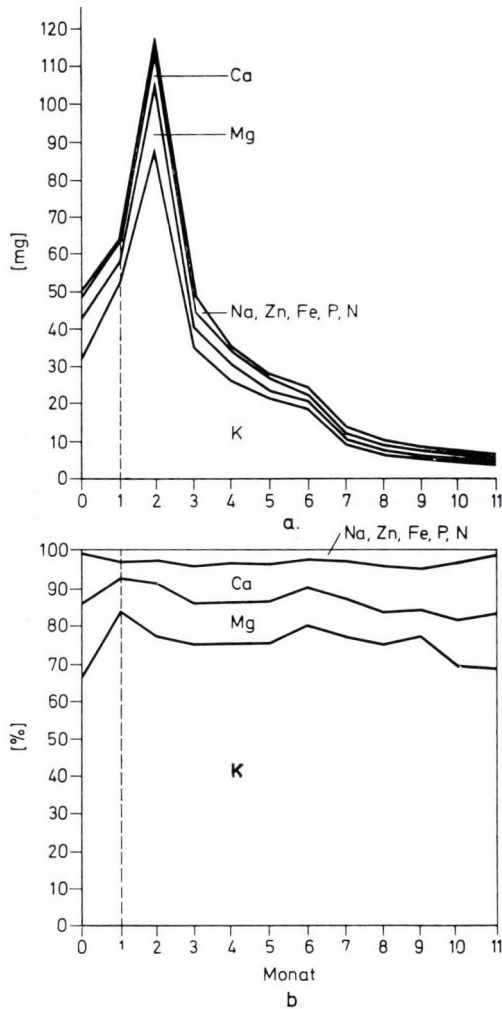
Abb. 5. Euonymus verrucosa

Den Abbau der im grünen und trockenen Stadium gesammelten Blätter (*Acer tataricum*, *Cornus mas*, *Quercus cerris*, *Q. petraea*) verglichen, mag festgestellt werden, daß der Abbau der grünen Blätter schneller vor sich geht und in kürzerer Zeit eine größere Menge biogener Elemente frei werden, als aus den trockenen Blättern. Natürlich hängt die Quantität der in absolutem Wert freigewordenen biogenen Elemente auch von der chemischen Zusammensetzung der Blätter ab.

Die Menge der im Laufe der 11, bzw. 19 Monate dauernden Inkubation freigewordenen biogenen Elements ist in den einzelnen Arten folgende:

11 Monate andauernde Inkubation mit grünen Blättern

Acer campestre	289,3 mg
A. tataricum	268,6 mg
Cornus mas	438,2 mg
Crateagus oxyacantha	293,2 mg
Euonymus verrucosa	375,7 mg
Ligustrum vulgare	529,6 mg
Lonicera xylosteum	466,9 mg
Quercus cerris	297,4 mg
Q. petraea	213,1 mg

19 Monate andauernde Inkubation mit trockenen Blättern

Acer tataricum	290,5 mg
Cornus mas	435,9 mg
Quercus cerris	211,5 mg
Q. petraea	228,1 mg
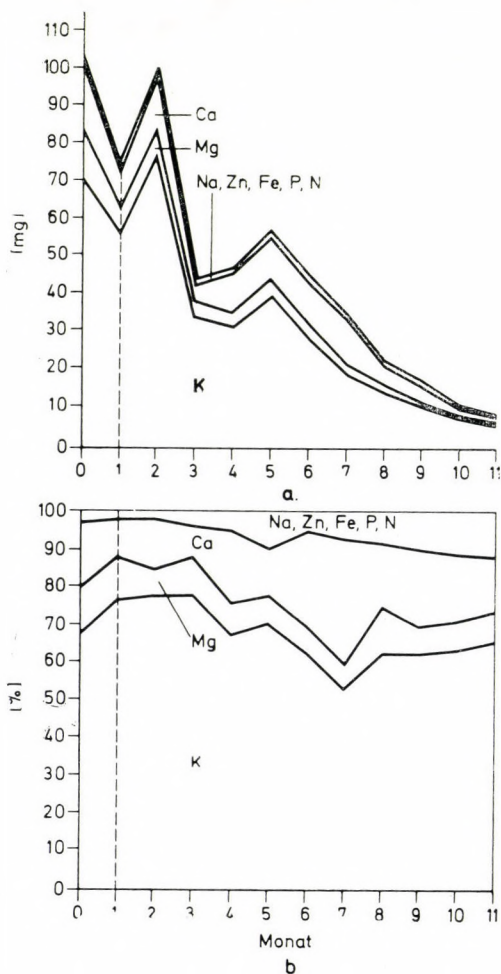
Abb. 6. Ligustrum vulgare
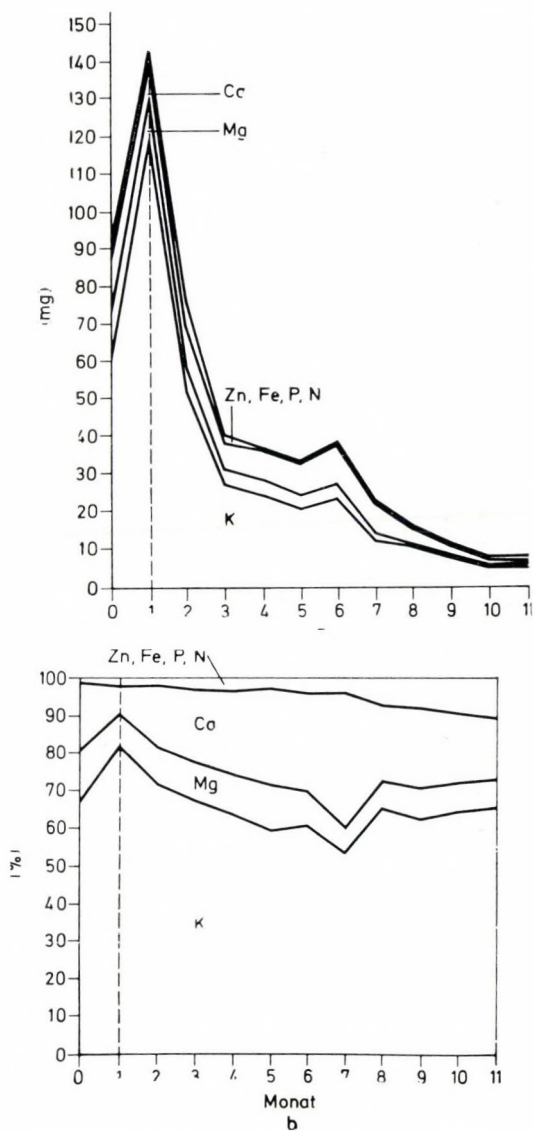
Abb. 7. Lonicera xylosteum

Bei den einzelnen Arten ist die Menge der herausgelösten biogenen Elemente vor allem von dem K-Gehalt der Blätter bestimmt (vgl. Tabelle 1), welche Tatsache auch durch die Daten der vorgenommenen Regressionsanalyse (r: 0.882, p: 0.1%) bewiesen wurde.

In Anbetracht der Menge der freigewordenen Elemente gestaltete sich die Reihenfolge der Arten (in Richtung Abnahme) folgendermaßen:
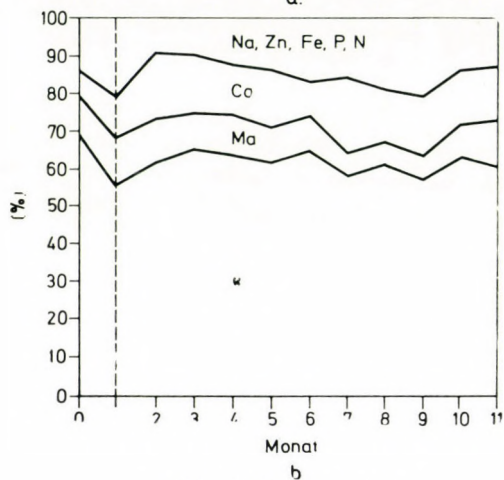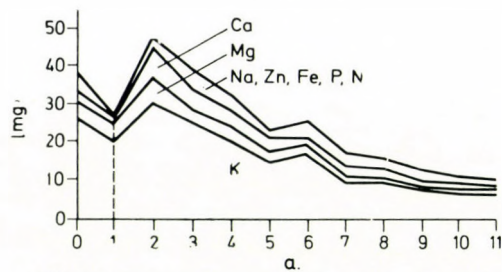
Abb. 8. Quercus cerris
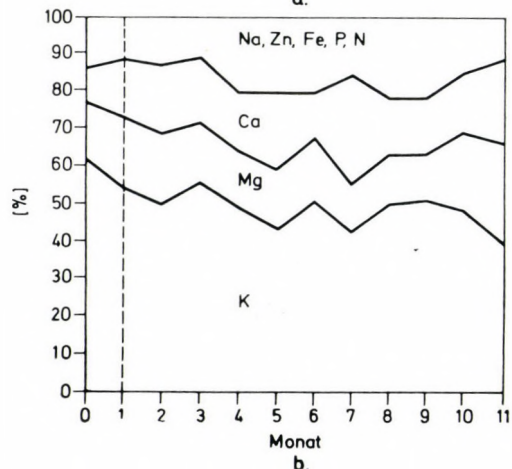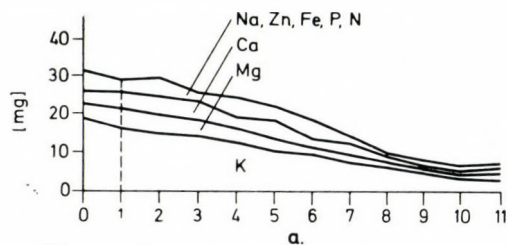
Abb. 9. Quercus petraea
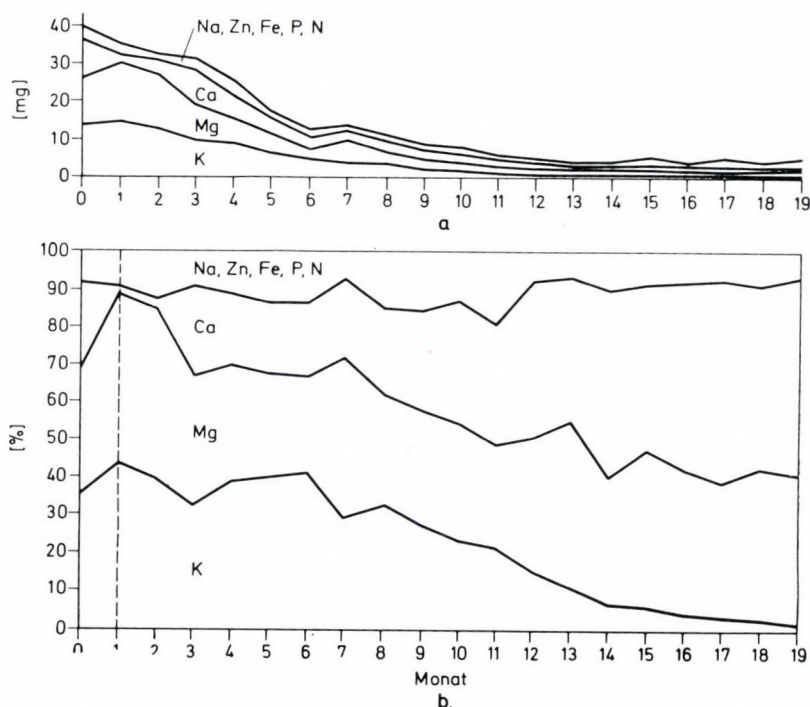
Abb. 10. Acer tataricum

Ligustrum vulgare—Lonicera xylosteum—Cornus mas—Euonymus verrucosa—Crataegus oxyacantha—Acer campestre—A. tataricum—Quercus cerris—Q. petraea.

Die quantitative Reihenfolge der aus den grünen und trockenen Blättern der einzelnen Arten ausgelösten biogenen Elemente ist folgende:

Acer campestre (grüne Blätter)	K>Mg>Ca>N>Mn>P>Na>Zn>Fe
A. tataricum (grüne Blätter)	K>Ca>Mg>Mn=N>Na>Zn>Fe>P
(trockene Blätter)	K>Mg>Ca>N>Na>P=Zn>Mn=Fe
Cornus mas (grüne Blätter)	K>Ca>Mg>N>Na>P>Mn>Zn>Fe
(trockene Blätter)	K>Mg>Ca>N>Na>P=Zn>Mn>Fe
Crateagus oxyacantha (grüne Blätter)	K>Mg>Ca>N>Na>P>Zn=Mn>Fe
Euonymus verrucosa (grüne Blätter)	K>Mg>Ca>N>Zn>Na>P>Mn>Fe
Ligustrum vulgare (grüne Blätter)	K>Ca>Mg>N>Na>Mn>P>Zn>Fe
Lonicera xylosteum (grüne Blätter)	K>Mg>Ca>N>Na>Zn>Fe>P>Mn
Quercus cerris (grüne Blätter)	K>Ca>Mg>N>Mn>P=Na>Zn>Fe
(trockene Blätter)	K>Ca>Mg>Mn>N>Na>P>Zn>Fe
Q. petraea (grüne Blätter)	K>Mg=Ca>N>Mn>P>Na>Zn=Fe
(trockene Blätter)	K>Mg>Ca>N>Mn>Na>P>Zn>Fe

Bei sämtlichen untersuchten Arten ist in größter Menge Kalium freigeworden, ihm folgten Ca, bzw. Mg. Aus den grünen Blättern werden in
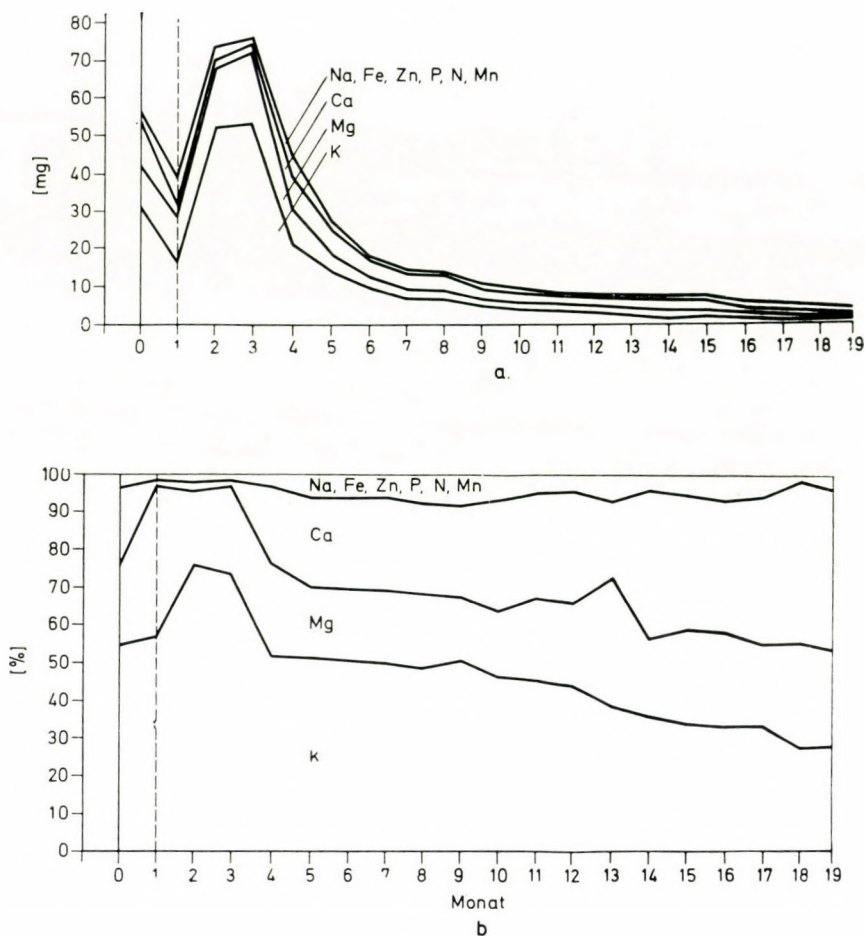
Abb. 11. Cornus mas

11 Monaten 80—90 Prozent des K-Gehalt, aus den trockenen Blättern dagegen in 19 Monaten 50—70% herausgelöst.

Das rapide Freiwerden des Kaliums wird dadurch hervorgerufen, daß im Prozentverhältniß der herausgelösten Elemente Kalium vorherrscht. Dieses Verhältnis ändert sich bei den trockenen Blättern nach einem 10—15 Monate andauernden Abbau, weil sich wegen der raschen Herauslösung des Kaliums das K-Prozentverhältnis verringert, der Prozentsatz von Kalzium und Magnesium dagegen zunimmt (Abb. 9—13).
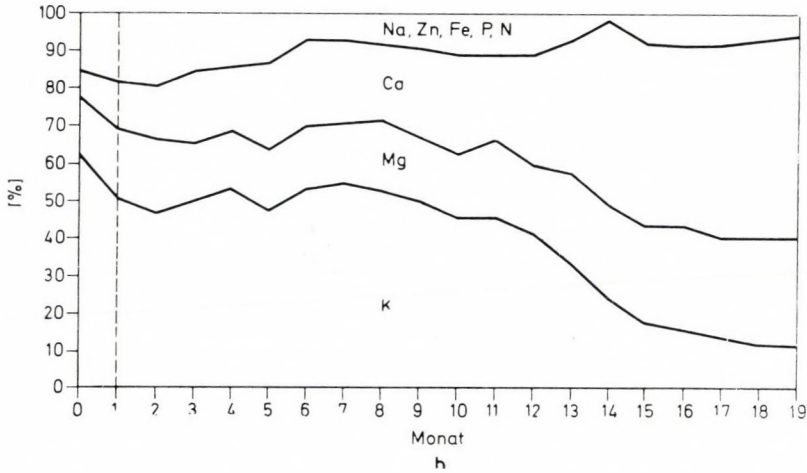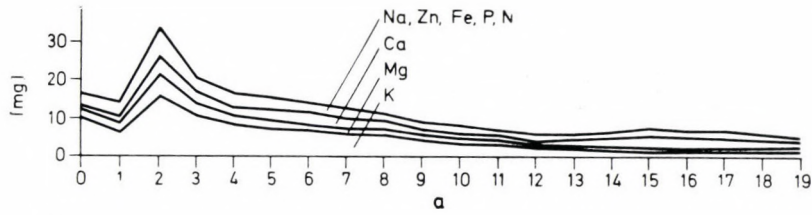
Abb. 12. Quercus cerris
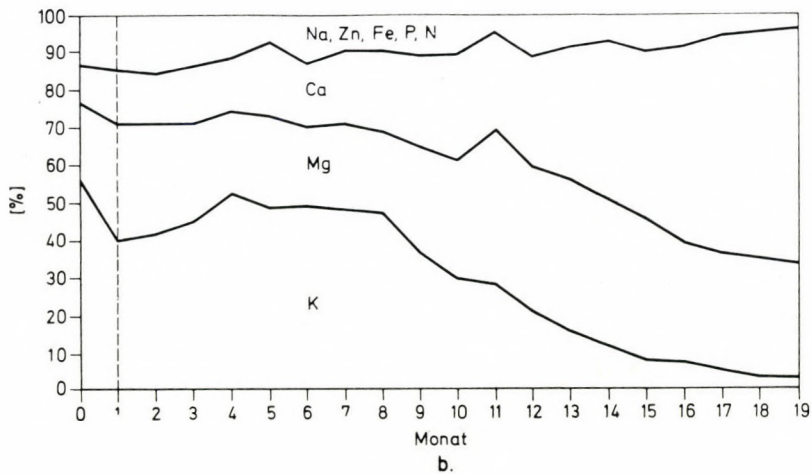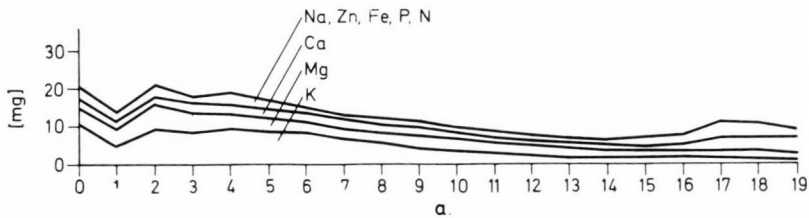
Abb. 13. Quercus petraea

Zusammenfassung

Den unter Laborverhältnissen durchgeführten Untersuchungen des Abbaus gemäß geht die Dekomposition der grünen Blätter — aufgrund des Gewichtsverlustes und der Menge der freigewordenen biogenen Elemente — rascher vor sich, als die der trockenen Blätter. Der raschere Abbau steht vermutlich mit dem höheren Nitrogengehalt der Blätter im Zusammenhang.

Im Gang des Abbaus können 3 Phasen unterschieden werden in der ersten Phase, d.h. in den ersten drei Monaten des Abbaus wird eine große Quantität biogener Elemente frei. In der 4—5 Monate andauernden zweiten Phase wird das Freiwerden der Elemente verlangsamt, während in der dritten Phase in verhältnismäßig gleichmäßiger Verteilung monatlich eine sehr geringe Mange von Elementen herausgelöst wird.

Mehr als 50 Prozent der biogenen Elemente werden in den ersten 4—5 Monaten der Dekomposition frei.

Das Freiwerden einer großen Menge von biogenen Elementen erfolgt in den ersten drei Monaten vor allem bei solchen Arten, in deren Blättern sich der K-Gehalt um 1 Prozent bewegt.

Das am raschesten und in größter Menge ausgelöste Element ist das Kalium.

Die Blätter einiger Straucharten (*Cornus mas*, *Euonymus verrucosa*, *Ligustrum vulgare*, *Lonicera xylosteum*) »geben« annähernd zweimal soviele biogene Elemente ab, wie die Blätter der Bäume *Quercus cerris* und *Q. petraea*.

Die Entstehung des artenreichen Unterwuchses in einer dichte Strauchschicht aufweisenden Waldgesellschaft mag mit dem raschen Abbau der Blätter der Straucharten, sowie mit dem Freiwerden einer großen Menge biogener Elemente im Zusammenhang stehen. Diese Annahme kann natürlich nur durch die mehrjährigen Ergebnisse (s. Tóth et al., 1975) einer auf dem Felde durchgeführten experimentalen Abbau-Forschung bestätigt werden.

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PHLEUM STUDIES II

PHLEUM HUBBARDII A NEW SPECIES OF POACEAE (GRAMINEAE)

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A new series (Series *Pratenses*), and a new species of *Poaceae* (*Gramineae* the *Phleum Hubbardii* D. Kov. (diploid: $2n = 14$) are reported. The holotypes of Linnaeus *Phleum nodosum*- and De Candolle's *Phleum bertolonii* are described. Earlier, the diploid *Phleum pratense* L. was identified with either of these two types. The measurements of the two holotypes are compared with those of the here-described diploid ($2n = 14$) *Phleum Hubbardii* D. Kov. — and of the hexaploid ($2n = 42$) *Phleum pratense* L. It has been stated that the two holotypes mentioned above are not diploid, but are identical with the underdeveloped, "depauperate" hexaploid. *Ph. pratense* L. of stunted growth. By comparing in general the here-described diploid *Ph. Hubbardii* D. Kov. and the hexaploid *Ph. pratense* L. with regard to some of their characteristics and sizes of organs it can be stated that the differences between the two species are not only quantitative (the difference between the smaller diploid and greater hexaploid sizes of organs), but also qualitative (9 out of the 10 characteristics examined are different) in nature.

Introduction

The author has been dealing with *Phleum pratense* L. for about three years. Besides studying the plants collected from natural habitats, observations were also made on the samples of the two species grown under identical ecological conditions in experimental gardens. In this way, the differences caused by habitat factors are eliminated and on the other hand, the deviations arising as a result of polyploidy or different growth habit become more pronounced.

In previous paper I tried to compare the external and internal morphological characteristics of the fertile culms of the diploid ($2n = 14$) and the hexaploid ($2n = 42$) *Phleum* (Nordenskiöld, 1945; Darlington—Whylie, 1955), in order to distinguish the two species and also to point out the differences in their growth (Kováts, 1976).

In the course of these works light has been thrown upon the fact that *Phleum nodosum* Linnaeus, 1759, and *Phleum bertolonii* De Candolle, 1813., which used to be considered as the holotypes of the diploid $2n = 14$ *Phleum*, are in fact underdeveloped "depauperate", specimens of stunted growth of the hexaploid $2n = 42$ *Phleum pratense* L. The earlier authors used to identify the diploid phleum with the holotype of Linnaeus or De Candolle, without

any examination of the holotypes mentioned. Therefore, I had to give a new name and description together with a new holotype, by pointing out at the same time the genotypic characters. On the basis of all these, the diploid *Phleum* can be distinguished unambiguously from the hexaploid *Phleum*. In the literature, even in some of the works which consider the diploid *Phleum* as an independent species and separate it from the hexaploid *Ph. pratense* L., the subareal tuberosus internodes of stem are taken as basis, which is a misjudgement of the differentia specifica (LINNÉ, 1759; HOST, 1801—1809; DE CANDOLLE, 1813; BERTOLONI, 1833; GROSSHEIM, 1928; HERMANN, 1956; BUTSCHER, 1961), or they consider only the differences in sizes as decisive when separating the two species (CLAPHAM—TUTIN—WARBURG, 1959).

In my previous work (KOVÁTS, 1976) even I myself used the *Phleum bertolinii* DC. designation, after the German worker (HERMANN, 1956) and the English workers (DANDY, 1958; CLAPHAM—TUTIN—WARBURG, 1959, 1962; HUBBARD, 1968) for the designation of the diploid *Phleum*.

In my present work a new *Phleum* series, a polyploid line, the Series *Pratenses* D. Kov. has been erected. This is not new in the *Poaceae* (*Gramineae*) research, for J. UJHELYI in the course of his evolutionary studies has already established evolutionary polyploid lines, in the genera *Sesleria* and *Koeleria* (UJHELYI, 1959, 1961—1974).

Materials and methods

We collected the type specimens together with József UJHELYI and Sándor TÓTH in Hungary, from the dry meadow near the village Hárskút in the Bakony Mountains, at the entrance of the Esztergáli valley, at an altitude of 400—450 m. Sándor TÓTH led us to this excellent habitat. The specimens which were collected by us are deposited in the Herbaria of the Natural History Museum of Budapest (HB).

Stems from the above materials were planted in experimental gardens together with the samples collected from other areas, under identical conditions.

For a comparison between the diploid and the hexaploid species, the new holotype and the DE CANDOLLE holotype, skin preparations from culms (UJHELYI, 1954) and collodium replicates (LOVAS, 1960; SÁRKÁNY-SZALAI, 1964) were made from the uppermost internodes of the culms bearing the panicle, where the culm becomes free from the leafsheaths. The photographs taken of the epidermis are of identical magnification.

A table is given for a comparison between the holotypes (Table 1, Group A) and for the general characteristics and sizes of the diploid and hexaploid *Phleum* (Group B) (CLIFFORD, 1969; SNEATH-SOKAL, 1973; SZUJKÓ-LACZA—SEN, 1976). The measures are in general from the average of about 50 data (Group B). With the exception of the types, the minimum and the maximum averages are also given for the various organs (Group B, minimum $\bar{x}$ and maximum $\bar{x}$). After the data of length and diameter, the ratios are also given. The characters and the sizes are given in serial numbers, there are altogether 19 of them; the characters that exist are given a + sign, the missing characters are indicated with a — sign. The non-establishable and non-measurable characters are marked & in types of Group A. The characters and sizes of the LINNAEUS holotype, and HUBBARD's data (1956) are given on the basis of correspondance with HUBBARD. After the characters and the measures, the development of the specimens examined (it is only different with the types), and the phenological stages are marked after SZUJKÓ-LACZA—FEKETE (1973) (Table 1).

Results and discussion

The analysis of the Linnaeus and De Candolle holotypes

I had no opportunity to see personally the *Phleum nodosum* type or types of LINNAEUS (1759). I, therefore, made a personal communication with the world famous researcher of grasses, Dr. C. E. HUBBARD, to seek his comments as to why he used in the second edition of his book (HUBBARD, 1968) the designation *Phleum bertolonii* after DE CANDOLLE (1813), instead of *Phleum nodosum* L. (1759) used in the first edition (HUBBARD, 1954). HUBBARD's remark, for which I owe a debt of gratitude to him, is represented below:

"There are two speciemens under *Phleum nodosum* in the Linnean Herbarium, London, numbered 81.2 and 81.3.

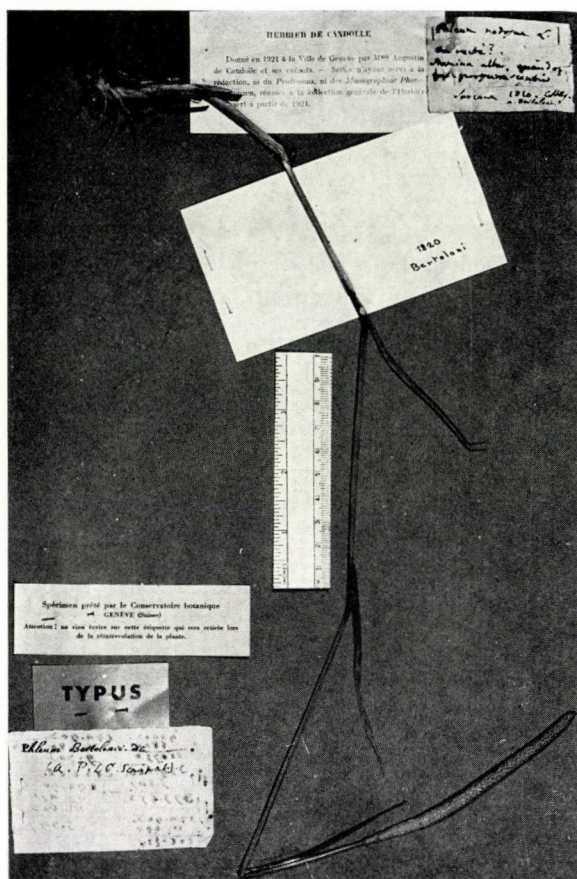
Sheet 81.2 is labelled at the base "*nodosum*" in LINNAEUS's handwriting. The sheet also bears a small stuck-down label on which is written "*Gramen typhoides*, vol. 3, p. 154, no· 14", and "*Phleum nodosum*". The first part ("*Gramen typhoides*") was queried as being the writing of SEGMIR, by SAVAGE in his account of the Linnean Herbarium, but it does not agree with the extract of SEGMIR's handwriting given by SAVAGE. It resembles the handwriting of G. A. MURRAY (No. 38, in SAVAGE's work). The "*Phleum nodosum*" is in the hand of LINNAEUS. On this sheet there are four separate pieces of culm, bearing one or two leaves, and each with an inflorescence, together with one piece of the lower part of the culm with the basal internode swollen and 13 mm long by 4 mm wide at the base. The leaf-blades are 4.5—6 cm long, involved (about 2.5 mm wide when opened out). The spikes are cylindrical, 3.5—5.5 cm long by 5—6 mm wide. The spikelets are 2.7—3 mm long, and with 0.5—1.5 mm long awns.

This is the plant I first accepted as the type of *Phleum nodosum* L. which I studied for Dr. W. B. TURILL's transplant experiments (published in the Journal of Ecology) when he compared the growth of the diploid (*Ph. nodosum*) and hexaploid (*Ph. pratense*) in various types of soil. It was also used by me in the first edition of "Grasses". Later I found it was not the type, having been added to the Linnean Herbarium after 1759.

Sheet 81.3 is labelled at the base "*Phleum nodosum*" and "A". The "A" and other letters of the alphabet were given to new species described in the "Systema Naturae" ed. 10. On the back of the sheet has been written "*Gramen nodosum spicatum* b. B. Prodr". The specimen consist of a single culm doubled up on the sheet, with the upper part (one leaf and spike) broken from the bottom half of the plant. The basal internode is ± bulbous, 17 mm long × 5 mm wide at the base. The culm is very slender, about 54 cm long, geniculate, unbranched, about 2 mm wide above the bulbous zone. The leaf-blades are up to 20 cm long, 2.5 mm wide. The spike 18 mm long × 7 mm wide (including awns) ± ovate-oblong, with reduced sterile spikelets at the base. The best developed spikelets are 3 mm long, with awns 2 mm long, while the other spikelets (poorly developed) have shorter awns.

The specimen agrees very well with the diagnosis of *Phleum nodosum* which LINNAEUS gave in the Syst. Nat. (1759), and moreover the name "*Ph. nodosum* A" is in the handwriting of LINNAEUS, the letter "A" coming from the "Syst. Nat.", showing that LINNAEUS had the specimen before the Second Edition of the "Species Plantarum", where *Phleum nodosum* is numbered "2". This specimen must be the type (holotype) of *Phleum nodosum*. Unfortunately it is a depauperate plant of the larger *Phleum pratense* L. It is similar to specimens from Sweden and Scotland, which have small + normal large inflorescences on the same plant". (C. E. HUBBARD 5. 5. 1956) . . . "As a result of discovering that this specimen was a depauperate specimen of *Phleum pratense* L., it became a synonym of that species. The next name for the diploid, previously named *Ph. nodosum* L. proved to be *Phleum bertolonii* DC." . . .

C. E. HUBBARD 5. XI. 1975

The type specimen of DE CANDOLLE's *Phleum bertolonii* was obtained by the Courtesy of the Conservatoire et Jardin Botaniques Ville de Geneva. Unfortunately the specimen turned out to be a stunted flowering form of the

Photograph 1. Phleum bertolonii, the holotype of De Candolle

large hefty *Phleum pratense* L.; the upper most internode having grown out only a little of the leaf sheath and the upper part of the panicle having spikelets still in flowering while the lower ones having completed their blossoming (Table 1, Group A. Photograph 1).

At the beginning I had doubt about the originality of the De Candolle type specimen since the time of collection, in the hand-writing of Bertoloni the collector, could be read either as 1810 or 1820. This uncertainty was even increased by the circumstance that recently somebody wrote on the label which held the plant to be of 1820 (Photograph 1). In this case this description should be related to a specimen collected after 1813 and therefore could not be a holotype. My doubts were eliminated when to my inquiry I received a reply from Geneva that there was no more *Ph. bertolonii* DC. specimen collected by Bertoloni in De Candolle Herbarium. Several *Phleum* plants

Photograph 2. Holotype of *Phleum Hubbardii* D. Kov.

were described by De Candolle, but none of them was from Italy. The specimen examined by me corresponded to the description (De Candolle, 1813, p. 132).

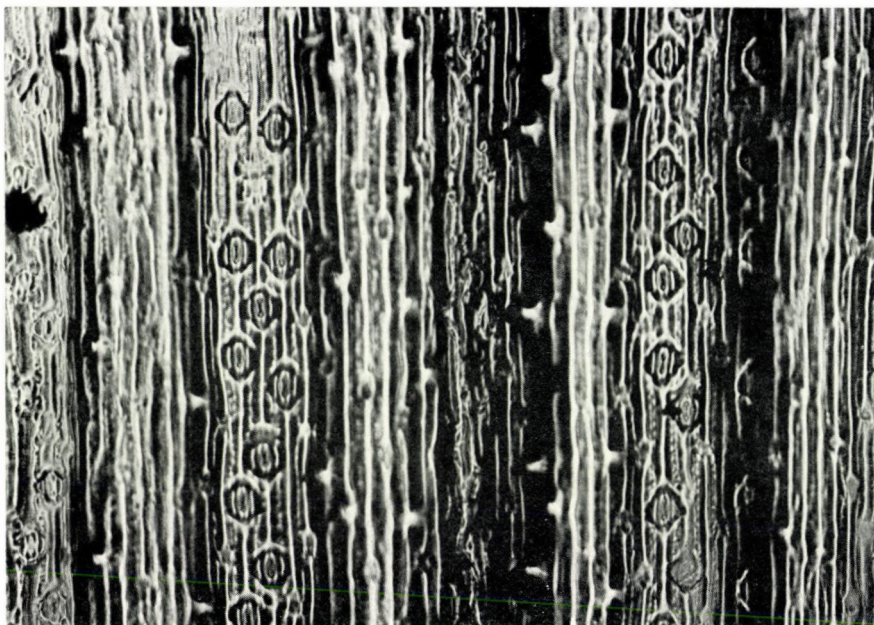
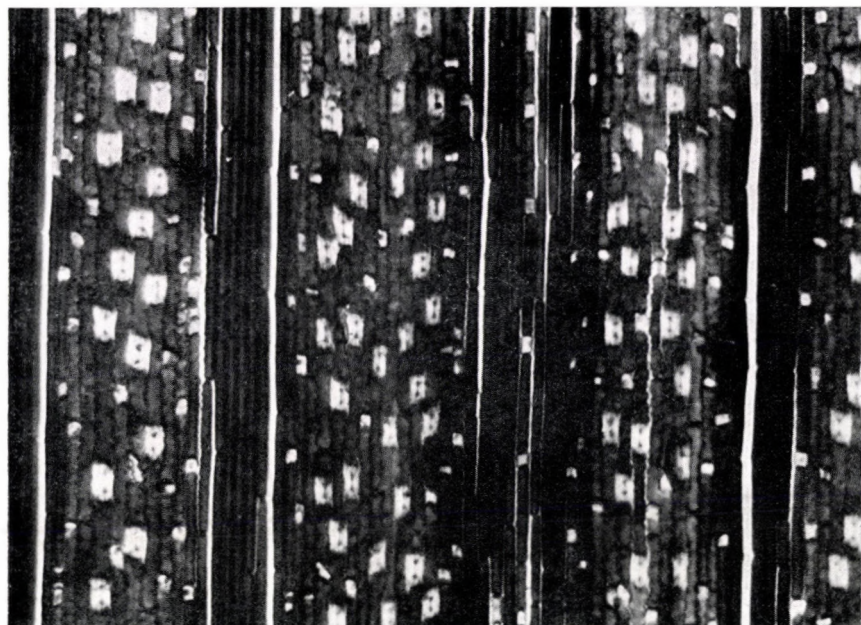
It is further proved by the following facts that, only the specimen examined by me could be the holotype of De Candolle. The habitat of the specimen is written as Sarsana (also according to the description, De Candolle, 1813), and there are a few remarks, date, and the hand-writing of the collector Bertoloni: "*Phleum nodosum* L. An recta? Stamina alba, quando que purpurascentia Sarsana 1810. CMG. n. Bertoloni". Besides, in the hand-writing of De Candolle the following can be read on the type sheet: "*Phleum Bertolinii* DC. (a. P. DC. Scripsit)" (Photograph 1).

As has been mentioned in the foregoing paragraphs the holotype of De Candolle (1813) *Phleum bertolinii*, on the basis of its measures, unfor-

Table 1

Comparison of various characters and sizes (in mm) of the Linnean Phleum nodosum and De Candolle Phleum bertolonii holotype and of the diploid Phleum Hubbardii D. Kov. holotype — Group A — and in general of the diploid Phleum Hubbardii D. Kov. and the hexaploid Phleum pratense L. grown in the identical habitat — Group B

Characters	*Group A* Holotypes						*Group B*			
	holotype of LINNAEUS		holotype of DE CANDOLLE		new holotype *Phleum Hubbardii* D. Kov.		*Phleum Hubbardii* D. Kov.		*Phleum pratense* L.	
		breath/ length		breath/ length		breath/ length	minimum $\overline{X}$ maximum $\overline{X}$	breath/ length	minimum $\overline{X}$ maximum $\overline{X}$	breath/ length
1. Basal internode (usually) tuberous + or not —	+		+		+		+		+	
2. Measurement of the length lowermost tubers and breath	17 5	0.29	10 12	1.20	5 7	1.40	7—10 5—8	0.71— 0.80	10—25 8—15	0.80— 0.60
3. Extravaginalis innovation present + or absent —	&		&		&		+		—	
4. Intravaginalis innovation present + or absent —	&		&		&		—		+	
5. Innovation present + absent — in upper internodes of the stems	&		&		&		+		—	
6. Shoots often partly vegetative + or not —	&		&		&		+		—	
7. All of the shoots usually fertile + or not —	&		&		&		—		+	
8. Shoots usually prostrate or procumbent	+		+		+		+		—	
9. Shoots spreading on the ground specially in autumn + or not —	&		&		&		+		—	
10. Culms (mostly) maintaining upright growth + or not —	—		—		—		—		+	
11. Culms slender/stout	+		—		+		+		—	

12. Measurement of culms										
length	540		590		530		300—800	0.0033—	700—1500	0.0021—
and		0.0037		0.0033		0.0028				
breath	2		2		1.5		1—1.5	0.0018	1.5—3	0.0020
13. Number of nodes present	&		6—7		5—9		5—10		6—8	
14. Length of the leafsheaths	&		20—105		20—100		20—170		100—200	
15. Measurement of										
leafblades length	200		90		40—70	0.050—	50—120	0.040—	120—300	0.050—
and		0.012		0.033						
breath	2.5		3		2—2.5	0.035	2—3	0.025	6—9	0.03
16. Length of the ligules	&		5		1.5—3		2—4		5—6	
17. Measurement of length	18		105		70		10—90	0.30—	60—150	0.116—
panicles and		0.066		0.085		0.085				
breath	7		7		6		3—6	0.066	7—10	0.066
18. Length of the spikelets	3 (the best developed)		3		2—2.5		2—2.5		3—3.5	
19. Length of the awns	2 (the best developed)		1		1		0.5—1		1—2	
Examined plant(s) well developed + or not —	under developed "depauperate"		stunted growth		+		+		+	
Phenological stages	&		24, 32—33, 42		24, 32—33, 42		24, 33, 42		24, 33, 42	

Photographs 3. and 4. Epidermal structure of the culm holotype of the new species, *Phleum Hubbardii* D. Kov. and DE CANDOLLE's holotype *Phleum bertolonii* culm, below the panicles (collodium replicas, ×200 in every case)

Photographs 5. and *6.* Epidermal structure of diploid *Phleum Hubbardii* D. Kov. and hexaploid *Phleum pratense* L. culms, below the panicles (skin preparation, ×200 in every case)

tunately, is identical with a robust blossoming *Ph. pratense* L. which has not yet reached its final height. This is indicated by the width of lowermost tuber, the thickness of the culm, the length of the ligules, the length and width of the panicle and the large size of the spikelets (Table 1, Group A; Photograph 1). The identical structure of the epidermis also testifies this, besides the external morphological comparison (first of all the widths of the costal and intercostal zones are similar; Photographs 3—6). An exception is the short culm which is a consequence of the stunted growth. It is especially the uppermost internode below the panicle (Photograph 1) that is short, 18 cm, in comparison with the other parts of the culm. By comparing the diploid and the hexaploid *Phleum* — on the basis of the averages of about 200 data — it can be observed that the uppermost internode of the specimens of the diploid species that have reached its full height is 19 cm, while that of the hexaploid *Ph. pratense* L. is 33.4 cm (KOVÁTS, 1976).

The holotype of LINNAEUS (1759) *Ph. nodosum* (the one which can be the holotype on the basis of the time of collection) is also an underdeveloped, "depauperate" form of a *Ph. pratense* L. (personal communication of HUBBARD, 1956); this is also shown by its measures (Table 1, Group A). The length measure of the tuber is remarkably great, 17 mm (Table 1, Group A, 2); in the *Ph. pratense* L. it is 10—25 mm (Table 1, Group B, 2). The length measure of the leaf-blades is also extremely great, 200 mm ("up to 20 cm long", HUBBARD, 1956) (Table 1, Group A, 15); in the *Ph. pratense* L. it is 120—130 mm (Table 1, Group B, 15). The spikelets are long, 3 mm ("the best developed spikelets are 3 mm long, with awns 2 mm long, while other spikelets (poorly developed) have shorter awns" (Table 1, Group A, 18); in the *Ph. pratense* L. it is 3—3.5 mm (Table 1, Group B, 18). The shortness of culm, 540 mm (Table 1, Group A, 12). and especially the short size of the panicle, 18 mm (Table 1 Group A, 17) is a consequence of the specimen being underdeveloped, "depauperate".

The diploid *Phleum* species is known from the literature (NORDENSKIÖLD, 1945; HUBBARD, 1954, 1968; CLAPHAM—TUTIN—WARBURG, 1962; HESS—LANDOLT—HIRZEL, 1967; BOR, 1970), but the type-specimens are hexaploid *Ph. pratense* L.-s. As a result of the incorrect analysis of the holotypes, or of the lack of its knowledge, it has been mistakenly identified with the diploid species, therefore the names applied for the diploid *Phleum* (*Ph. nodosum* L. and *Ph. bertolonii* DC.) are not valid.

Phleum Hubbardii D. Kov. Species nova

Syn.: *Ph. nodosum* L. pro. p. Linnaeus, C. (1759): Systema Nature, ed. 10. 871. *Ph. pratense* ssp. var. *nodosum* (L.) SREB. pro. p. Sreber, J. C. D. (1769): Beschreibung der Gräser nebst ihren Abbildungen nach der Natur. 1. 102. *Ph. bulbosum* Host pro. p. Host, N. T. (1809): Icones et Descriptiones Graminum Austriacum. 4. 12—13. *Ph. bertolonii* DC. pro. p.

De Candolle, A. P. (1813): Catalogus Plantarum Horti Botanici Monspeliensis. 151—152. *Ph. pratense* L. var. (?) *stoloniferum* (Host) Borbás, pro. p. Borbás, V. (1877—78): Mat. és Term.-tud. Közlem. 15. 308. *Ph. pratense* ssp. *nodosum* (L.) Richt. pro. p. Richter, K. (1890): Plantae Europeae. 1. 36. *Ph. pratense* var. *nodosum* Batt. et Trabut pro. p. Battandier et Trabut (1895): Flore de l'Algérie. *Monocotylednoes*. 144. *Ph. pratense* ssp. *Ph. vulgare* var. *Bertolonii* A. and G. pro. p. Ascherson, P. — Graebner, P. (1898): Synopsis der Mitteleuropäischen Flora. 2. 142. *Ph. pratense* var. *pilisense* Boros pro. p. Boros, Á. (1964): Agrobot. 5. 287—295.

Plantae perennes, graciles, usque 30—60 cm longae, laxe caespitosae, multicaules, recumbentes, innovationibus extravaginalibus, rhizomatibus multicaulibus, prorepentibus vel stoloniferis, bulboso-incrassatis, usque 6 cm longis, et 1,5—3 mm crassis, vaginis vetustis integris vel parum maceratis, brunneo-fuscis, laxe inflatis. Cormi steriles graciles, usque 20 cm longi. Culmi 1,5 mm crassi, basi usque tribulbosi, internodia inferiora 7 mm, superiora 20 mm longa. Vaginae foliorum usque 3 cm longae, laminae usque 9 cm longae et 2 mm latae, lanceolatae, ad apicem angustatae, marginibus, et costis minutissime scabriusculae. Ligulae foliorum usque 2 mm longae, integrae, obtusae. Culmi floriferi usque 53 cm longi, et 1,5 mm crassi, basin dense bulbose inflati usque ad 3 mm. Vaginae foliorum inferiorum usque 2,5 cm longae, superiorum usque 10 cm longae, laminae inferiorum usque 7 cm longae, et 2 mm latae ad apicem longe angustatae, superiorum usque 4 cm longae, et 2,5 mm latae, gradatim angustatae, marginibus et nervis minutissime scabriusculae. Ligulae inferiores usque 3 mm longae, superiores usque 1,5 mm longae. Paniculae spiciformes, usque 7 cm (8—9 cm) longae, et 0,6 cm crassae, dense oblongo—cylindricae, pallide virescentes, albescentes, pedicelli spiculorum brevissimi, in rachide 1—5 spiculis. Spiculae parvae, sine aristis 2—2,5 mm longae, aristis 1 mm longis, et sine ciliis 1 mm latae, uniflorae, glumae oblongae, truncatae, breviter aristatae, carinis dense ciliatae, ad marginem pallidae-hyalinae, gluma inferior 0,6 mm lata, ad marginem albide hyalina, minutissime remote sericea, marginibus laxe longeque ciliatis. superior 0,8 mm lata, marginibus glabris, lemma 1,5—2 mm longa, in apice minutissime denticulata, palea 1,5 mm longa, bicarinata. Antherae 1,5—1,8 mm longae.

Habitat in graminosis siccis.

Holotypus (photographia 2) adest in Herbario Musei Historico-Naturalis Hungarici Budapestini (HB).

Holotypus: Hungaria occidentalis. In pratis siccis ad pag. Hárskút, montium Bakony-hegység, prope opp. Veszprém. 30. IX. 1975. Leg. J. Ujhelyi S. Tóth et D. Kováts.

I dedicate the plant to Dr. C. E. Hubbard, the retired Deputy Director of Royal Botanic Gardens, Kew, a well known authority of grass systematics and a specialist of the flora of Australia and tropical Africa.

The plant is a perennial, slender herb 30—80 cm high, with 5—10 nodes (the number of nodes under garden conditions can even be 16), the upper internodes are 14—19 cm long, the lower ones 0.3—2.3 cm long (Kováts, 1976).

The stocks are multiculmed — the innovation is extravaginal — therefore they grow into loose tufts of branch and bush (Photographs 7 and 8). The culms are mostly geniculate, decumbent, loosely spread, and especially in autumn lie on the ground (Kováts, 1976).

The rhizomes are frequently multilobed; their external morphology being generally of two kinds. On the one hand, as a straight continuation of the above-ground culms, they are underground internodes, which have become more or less thickened tuberously. On the other hand, these tuberous internodes continue growing in stolons (stoloniferous rhizome). These are the parts of culms which are mostly the prostrate branches of the underground shoots

Photograph 7. Extravaginal innovation of *Phleum Hubbardii* D. Kov. the new culms break through the leaf sheaths (×8)

and thus they connect the old shoots remaining from the previous years with the new ones of the year, growing above-ground.

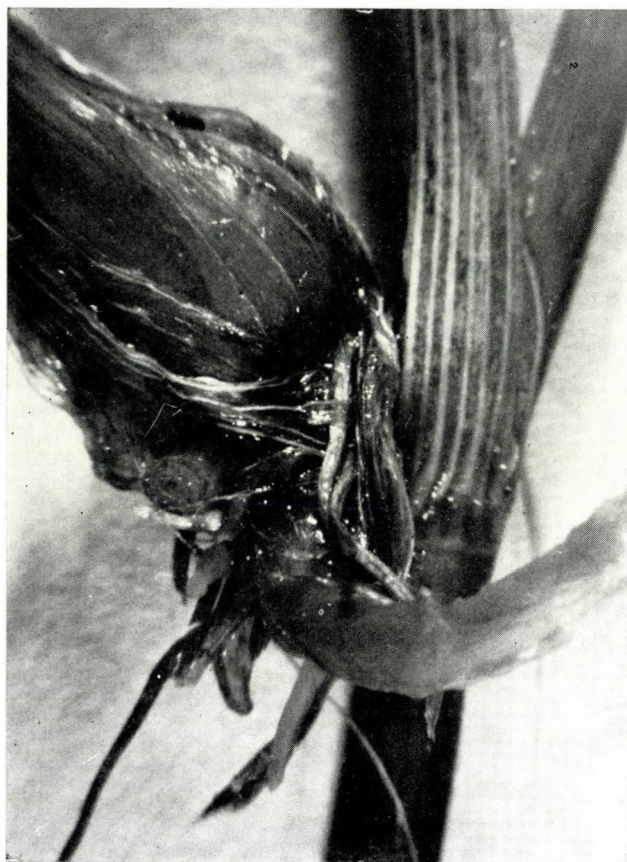
The underground 2—3 internodes of the culms mostly become thickened; after the works of TROLL (1937) and ARBER (1965) I also name these thickenings tuber. They are in general 7—10 mm long and 5—8 mm wide. Under garden conditions, the lower part of their upper internodes can also become tuberously thickened or newly developed lateral shoots can develop also from upper nodes, and often not only one (KOVÁTS, 1976). These newly developed shoots have roots which are mostly also tuberous and although the relative main axis are usually rootless, in certain cases they also develop roots (Photograph 9). In autumn, with the relative main axes bending down on to the soil, they come into contact with soil, then get into soil, easily become detached and live

Photograph 8. Phleum Hubbardii D. Kov. with extravaginal innovation, its loosely tufting stock; and the thick, non-tufting stock of *Phleum pratense* L. with intravaginal innovation

further as independent stocks. Thus the plant reproduces itself in a vegetative way (Kovács, 1976).

As generally in grasses of marshy land, here also cauline shoots develop. Three quarters of the shoots are fertile, bearing panicles, and only one quarter of them is vegetative. The latter are 14—45 cm long and 1—1.5 mm wide.

In autumn, the lower and middle internodes of the vegetative shoots are generally elongated, while the leaf sheaths and leaf blades become disorganized. The upper culm parts are on the other hand short, tuberously swollen, the leaves are green, and fresh (Photographs 10 and 11).

The dead, old leaf sheaths stretch apart and scale off during the early stage of development; their color being dark brown. The lower leaf sheaths of the fertile shoots are 2—10 cm long, the upper ones 7—17 cm. The lower

Photograph 9. New shoots with tuberously swollen base growing from the upper node of the culm, bearing roots even far above ground — in *Phleum Hubbardii* D. Kov. grown under garden conditions (×7)

leaf blades are 6—12 cm long, 2—2.5 mm wide; the upper ones 5—12 cm long and 2—3 mm wide. The leaves are lanceolate, tapering towards the apex along the edges and the ribs are minutely roughciliate. The lower ligules are 3—4 mm long and the upper ones 2—3 mm.

The leaf sheaths and leaf blades of the vegetative shoots are also usually shorter and often even narrower than those of the fertile shoots. The lower leaf sheaths are 2—4 cm long, the upper ones are mostly even shorter, 2—3 cm long. This shortness is especially conspicuous in autumn when the upper culm parts do not elongate but swell tuberously and ramify (Photographs 10 and 11). The lower leaf blades are 3—10 cm long, 2—3 mm wide, while the upper ones 3—6 cm long and 2—3 mm wide, lanceolate, narrowing towards

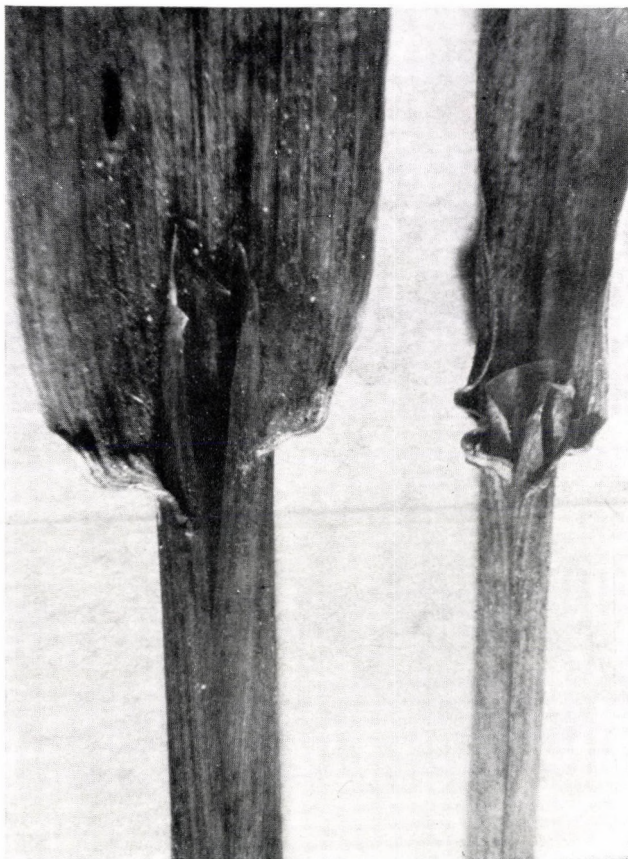
Photograph 10. Two vegetative shoots and a fertile shoot in the middle of *Phleum Hubbardii* D. Kov.

the apex. The ligules are 1.5—2 mm long, mostly split bluntly, and membranous (Photograph 12).

The panicles are 1—9 cm longer, 3—6 mm wide, compact, long-cylindrical, light green, often white, the rhachillas are extremely short, often ramifying (with 1—5 branches) (Photograph 13). The spikelets are rectangular, standing closely (Photographs 13 and 14), without awn they are 2—2.5 mm long, 1 mm wide, uniflorous; the awn is mostly 1 mm long. The glumes are long, blunt, with short awn; the carina is densely ciliate, of pale colour along the edge, pellicular, transparent. The inferior glume is 0.6 mm wide, along the edges white, pellicular, minutely hairy in the membranous sides sparsely along the edges, provided with long cilias. The superior glume is 0.8 mm wide and smooth along the edges. The lemmas are 1.5—2 mm long, finely toothed at their tip

Photograph 11. Vegetative shoot end, with tuberously swollen internode parts, of *Phleum Hubbardii* D. Kov.

(Photograph 15), the palea are 1.5 mm long carinate; the anthers are 1.5—1.8 mm long.

The frequent occurrence of the present species in Hungary is testified by the collection kept in the Herbarium of the Natural History Museum of Budapest. The plant is spread throughout the country (JÁVORKA, 1925; SOÓ—JÁVORKA, 1951; SOÓ—KÁRPÁTI, 1968; SOÓ, 1973), flowering from May to September. In xerotherm grasslands it is an important constituent of short-grasses of hills and plains and short rough grassland, on a wide range of soil HUBBARD, 1954, 1968; CLAPHAM—TUTIN—WARBURG, 1962). It is a wide-spread plant also in Europe (HEGI, 1927; NORDENSKIÖLD, 1945; HUBBARD, 1954, 1968; HESS—LANDOLT—HIRZEL, 1967).

Photograph 12. The bigger leaf sheaths of *Phleum pratense* L. and the smaller leaf sheaths of *Phleum Hubbardii* D. Kov. with their leaf blades and ligulas (×8)

Series Pratenses D. Kov., series nova

Rhizomatibus bulboso-incrassatis, paniculis anguste elongato-cylindricis, densis, si curvantur, non lobatis. Carina glumarum in mucronem gluma 2—4-plo breviorem abiens.

The lowermost, mostly underground internodes of the shoots are tuberously thickened. The developed panicles are elongated cylindrical, dense, remaining so when bent; do not become lobular. The glumes are elongated (2—4 mm long), blunt, with short awns.

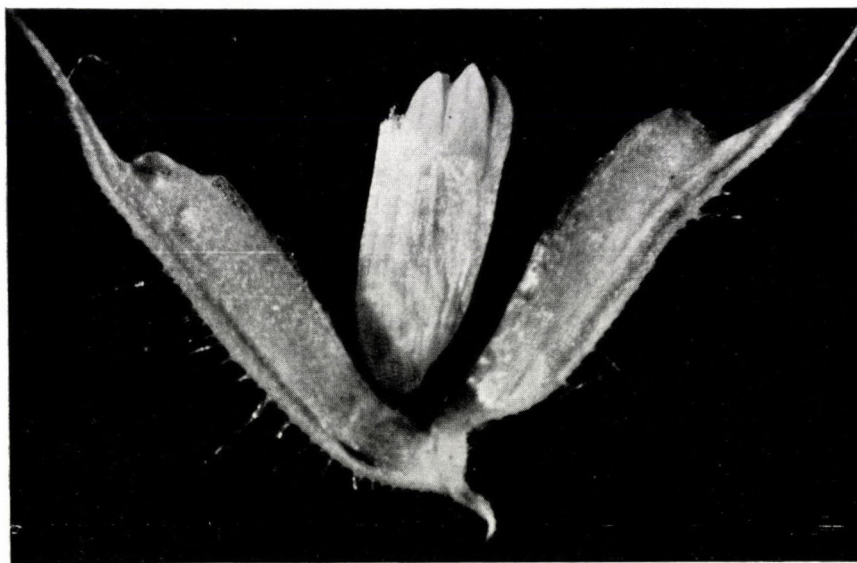
To this series belong the so far clarified diploid $2n = 14$ *Phleum Hubbardii* D. Kov. and the hexaploid $2n = 42$ *Phleum pratense* L.

Photograph 13. The spikelets of *Phleum Hubbardii* D. Kov. on short rhachillas, these are frequently ramifying (×20)

Comparison between the two species

The hexaploid *Phleum pratense* L. is a more robust and taller (70—150 cm) plant than the diploid *Ph. Hubbardii* D. Kov. Its fertile shoots mostly have fewer nodes, 6—8 (Table 1, Group B, 13); the uppermost internodes of the fertile shoots, below the panicle, are also much longer, 27—36 cm, than in the *Ph. Hubbardii* D. Kov. (Kováts, 1976).

The innovation of the multi-shooted stocks of *Ph. pratense* L. is intravaginal, therefore it is of densely grown branches and does not grow thick (Photographs 8 and 16), mostly goes upright, rarely geniculate, but does not lie onto the ground. The shoots of *Ph. Hubbardii* D. Kov. on the other hand, are loosely growing thick, with extravaginal innovation (Photographs 7 and 8), mostly geniculate, lie down the ground in autumn, thus they reproduce themselves vegetatively (Kováts, 1976).

Photograph 14. The bigger spikelets of the holotype of DE CANDOLLE *Phleum bertolonii* and the smaller spikelets of the holotype of the diploid *Phleum Hubbardii* D. Kov. (×28)

Photograph 15. An opened spikelet of *Phleum Hubbardii* D. Kov. in the middle the lemmas and the anthers (×23)

Photograph 16. The innovation of hexaploid *Phleum pratense* L. is intravaginal (×7)

The tuberous growth of the culm-parts (especially those under the ground) can be observed in both species (Table 1), these are not distinguising characters. Therefore, the two species cannot be separated on the basis of these characters, not even into infraspecific taxa as can be read in the works of the following authors: VISIANI, 1842: DEAKIN, 1854; HOOKER—WALKER—ARNOTT, 1860; BOISSIER, 1881; FIORI, 1896—1908; ASCHERSON—GRAEBNER, 1898—1902; SCHINZ—KELLER, 1900; BENTHAM—HOOKER, 1904; FIORI, 1923—25; JÁVORKA, 1925; HEGI, 1927; HAYEK—MARKGRAF, 1932; KOMAROV, 1934; BORDZILOWSKIO—LAVRENKO, 1940; KLAPP, 1950; SOÓ—JÁVORKA, 1951; DOSTÁL, 1954; ROTHMALER, 1963; JORDANOV, 1963; SOÓ—KÁRPÁTI, 1968; SAVULESCU, 1972; SOÓ, 1973). The authors mentioned above consider the tuberous, diploid *Ph. Hubbardii* D. Kov. of smaller built-up as a subspecies, variety, or synonym of the hexaploid *Ph. pratense* L. Tuberosity and the stoloniferous rhizome does

exist also in the hexaploid *Ph. pratense* L., only probably to a smaller extent. Tuberosity is of a smaller extent, primarily in the upper nodes, than in *Ph. Hubbardii* D. Kov., which is especially conspicuous in garden conditions. The same refers to the lateral shoots (Kovάts, 1976).

I have not yet met vegetative shoots in *Ph. pratense* L. According to my observations so far, from each of the surviving fertile lateral shoots, panicled shoots develop, in opposition to *Ph. Hubbardii* D. Kov. where (the difference is especially conspicuous in garden conditions) about a quarter of the shoots is vegetative; these are especially remarkable in autumn, they bend down onto the soil, their upper internodes are short and frequently develop the tubers, with green leaves (Photographs 10 and 11).

The leaf sheaths of the hexaploid *Ph. pratense* L. (10—20 cm long), and its leaf blades (12—30 cm long and 6—9 mm wide), as well as its ligules (5—6 mm long) are of much greater size than those of *Ph. Hubbardii* D. Kov. (Table 1, Group B, 14, 15, 16; Photograph 12). This difference in size exists also in the flowers; the panicles are 6—15 cm long, 7—10 mm wide, the spikelets are 3—3.5 mm long without their awns; awns are 1—2 mm long (Table 1, Group B, 17, 18, 19; Photograph 14). Similarly, this difference in size is manifest also in the epidermal structure of the two species (Photographs 3—6).

By comparing the 19 selected characters and organ sizes in the two *Phleum* species (Table 1, Group B), it can be observed that there are differences with respect to 9 characters (3—11) while there is agreement with respect to one of them (in the thickening of the lowermost internodes). Among nine size characters the number of nodes, the sizes of the organs of the hexaploid *Ph. pratense* L. are much larger, and the number of nodes in general is smaller (Kovάts, 1976). Sometimes the highest sizes of certain organs of the diploid *Ph. Hubbardii* D. Kov. correspond to one another, or they approximate to the lowest sizes of the hexaploid *Ph. pratense* L. (Table 1, Group B).

The *Ph. pratense* L., as against to *Ph. Hubbardii* D. Kov., is mostly frequent in mezotherm grasslands, water-meadows, and other low-lying grasslands, field margins, roadsides and waste places (Bentham—Hooker, 1904; Bews, 1929; Hubbard, 1954, 1968; Clapham—Tutin—Warburg, 1959, 1962). It is widely distributed in the whole country, and flowers from May to September (Jávorka, 1925; Soó—Jávorka, 1951; Soó—Kárpáti, 1968; Soó, 1973). Its frequent occurrence in Hungary is testified by the collection of the Herbarium in the Natural History Museum of Budapest. It is a wide-spread and cultivated plant also in Europe (Bentham—Hooker, 1904; Hegi, 1927; Klapp, 1950; Hubbard, 1954, 1968; Hess—Landolt—Hirsel, 1967; Máthé—Heszky, 1972).

Summary

The diploid *Phleum* has generally been misidentified with the holotypes of LINNAEUS (1759) and DE CANDOLLE (1813) by most of the workers; only some authors pointed out its characteristic features (NORDENSKIÖLD, 1945; HUBBARD, 1954, 1968; CLAPHAM—TUTIN—WARBURG, 1962; HESS—LANDOLT—HIRZEL, 1967; BOR, 1970). In most of the works the species characters are misjudged and it is not the diploid *Phleum* separated on the basis of differencia specifica which is described. In fact, the two holotypes are the hexaploid *Phleum pratense* L. The author has, therefore, reinterpreted the diploid *Phleum* species and named it *Phleum Hubbardii* D. Kov.

The *Ph. nodosum* type of LINNAEUS (1759) (the specimen collected before the description) is an underdeveloped, "depauperate" *Ph. pratense* L. specimen (HUBBARD's personal communication); this is testified by its sizes given by HUBBARD, especially the small panicle, and the shortness of the culm. In the same way, HUBBARD's statement that this type specimen is a hexaploid *Ph. pratense* L. is confirmed by his data as well, i.e. the large size of the tuber, the leaf blade and of the spikelets (Table 1, Group A).

The *Ph. bertolonii* type of DE CANDOLLE (1813) with its great sizes, is a hexaploid *Ph. pratense* L. specimen (Table 1, Group A, Photographs 1 and 3). An exception is the short culm, especially the brevity of the uppermost internode, which is a consequence of the blunt growth.

The thickening of the lowermost internodes, the elongated cylindrical form of the panicles, which remains cylindrical even after bending, are characters existing in both the diploid *Ph. Hubbardii* D. Kov. and the hexaploid *Ph. pratense* L. The two species discussed so far constitute an evolutionary line, the Series *Pratenses* D. Kov., series nova.

The diploid *Ph. Hubbardii* D. Kov. and the hexaploid *Ph. pratense* L. species have been compared independent of the types. The two species differ from each other not only in their organ sizes (Table 1, Group B, Photographs 1—6, 12 and 14), growth and vegetative distribution (KOVÁTS, 1976), but also in their innovations. The *Ph. Hubbardii* D. Kov. is of loose tuft, growing thick, its innovation extravaginal (Photographs 7 and 8), whereas the *Ph. pratense* L. is of dense tuft, with its stocks growing not thick, and its innovation intravaginal (Photographs 8 and 16).

In mezophytic grasses, in general, so also in the *Phleum* species, each of the lateral shoot is transformed into mature stem. The largest part of the *Ph. Hubbardii* D. Kov. stocks (in general, three quarters of the whole) are fertile, bearing panicles; only a small part (the remaining 1/4) consists of vegetative shoots, while in *Ph. pratense* L. I have for the time being observed only fertile shoots and have not yet seen vegetative shoots in it.

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ECOLOGICAL INVESTIGATIONS ON THE ALGAL COMMUNITIES IN THE CATCHMENT AREA OF RIVER ZALA. I

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The phytoplankton of the river Zala was examined from qualitative and quantitative viewpoints in the years between 1972 and 1976. In the course of the detailed taxonomical analysis of the phytoplankton 191 taxa were determined (*Cyanophyta* 11, *Euglenophyta* 8, *Xanthophyceae* 1, *Chrysophyceae* 2, *Bacillariophyceae* 125, *Cryptophyceae* 1, *Volvocales* 3, *Chlorococcales* 37, *Desmidiales* 3). The taxon number related to the whole period of investigations was studied. The number of taxa increased along the river toward the mouth. The taxon number of diatoms was the highest in all stations. The number of *Chlorococcales* taxa increased down the river and the taxon number ratio of *Chlorococcales: Bacillariophyceae*, as well. In the course of the quantitative examination of the phytoplankton, its percentage composition and diversity as well as the total algal counts and the quantity of chlorophyll-a in the volume of a unit of water was determined. *Chrysophyta*, which characterizes the phytoplankton and within it primarily the dominance of diatoms, decreased in the direction of the Zala mouth. The values of both the parameters of diversity and the degree of eutrophication increased in the direction of flow and reach in general their maximum value in the region of the mouth.

All these changes can be related to the considerable loads of plant nutrients mainly at the river reach below Zalaegerszeg and to the decrease in the flow velocity there.

Introduction

The river Zala occupies an outstanding position among the water courses flowing into Lake Balaton, with regard to either its discharge or its being loaded with plant nutrients. The Zala provides 30—60% of the surface run off flowing into Lake Balaton; it also provides approximately the 20—50% of phosphorus and the 30—40% of nitrogen, transported by the water streams flowing into the lake. The river directly exerts its effect in the south-western basin of the lake, first of all in the Keszthely Bay. It has a decisive role in the silting up of the bay and in its increasing eutrophication.

Despite the key role of the Zala in the formation of the water quality of the Balaton, there are only few publications dealing with the river from hydrobiological and waterchemical viewpoints. Algological data were published by FRANCÉ (1897) and TAMÁS (1971) based on examinations of the lower section of the Zala; and on those at several points of the river by UHERKOVICH

(1975). Entz (1959) mainly analysed the inorganic ion-composition of the water on the lower reach of the river.

Water chemical investigations, carried out since the beginning of the 70s, clarified — among other results — the role of the river in the turnover of nutrients in the lake and the effect of waste, primarily of industrial origin, flowing into it in the region of Zalaegerszeg (Tóth et al., 1975; Tóth, 1976).

The systematic hydrobiological examination of the river Zala and its tributaries began in 1970, in the laboratory of the West-Transdanubia District Water Authority. Between 1970 and 1972, saprobiological examinations were made; in the years between 1972 and 1976, the investigations were extended to measuring other parameters (total algal counts, chlorophyll-a) of the biological quality of water (Vizkelety, 1973; Vizkelety and Lenti, 1976). In that period the fundamental qualitative exploration of the phytoplankton of the river was also carried out.

In our present study, we investigated the changes in phytoplankton composition at four characteristic points of the Zala, in 1973 and 1975. In the course of taxonomical data processing, which rendered the foundations of quantitative examinations, we took into consideration the data of also other sites and times of sampling.

Material and method

The sampling sites (Fig. 1) and the sampling times are summarized in Table 1. In order to ensure the accurate measuring of the discharge, simultaneously with the sampling, the sampling site from Fenékpuszta was translocated into the hydrological measuring section built at 345 m above the river mouth in 1974. The examinations, made simultaneously at the two points, did not show significant deviations in the measured water-chemical and hydrobiological parameters, therefore they are marked with one symbol (F) and evaluated jointly. With regard to the samples from which quantitative analyses were also made there is an asterisk at the sampling time in Table 1.

For the taxonomical analysis of the phytoplankton, both spot samples and filtered (through plankton net No. 25.) ones were used. The microscopical examination of the samples was made on living, centrifuged material and on fixed, sedimentated one as well; mostly with phase contrast method, by means of Amplival (Zeiss) and Peraval-Interphako (Zeiss) microscopes. The conservation of the phytoplankton was carried out by Lugol's solution containing acetate and after it by formalin. The diatoms were examined from materials destructed by sulphuric acid, in preparations embedded in Canada balsam or Styrax. Scaled drawings and microscopic photographs were taken of the great majority of the algae observed during the analysis. The works of Brunnthaler (1915), Cleve-Euler (1951—1955), Felföldy (1972), Fott (1971), Gojdics (1953), Hortobágyi (1973), Huber-Pestalozzi (1955), Hustedt (1930), Pascher (1927), Starmach (1966), and of Uherkovich (1966) formed the basis of the determination.

The total algal counts were determined in fixed samples previously described. The algae was densed on Sartorius-Membranfilters of 0.45 μ pore diameter; after drying it was made transparent by means of Cellosolv (Felföldy, 1974).

The quantity of chlorophyll-a contained in a unit of water volume was determined from spot samples, after the hot methanol extraction of the material densified on membran filters, photometrically, using a Spekol photometer (Felföldy, 1974).

The diversity index and equitability were calculated on the basis of the following equations (Shannon and Weaver, 1963; Edden, 1971; Clifford and Stephenson, 1975).

$$H'' = - \sum_{i=1}^{s} \frac{n_i}{N} \log_2 \frac{n_i}{N}$$

where

H'' is the SHANNON—WEAVER diversity,
s is the number of taxa occurring in the sample,
n_i is the number of individuals belonging to the i-th taxon,
N is the total number of individuals,

Table 1

Localities and times of sampling

Locality	Symbol	River station (km)	Time
Őriszentpéter	Ő	115.350	1972. IX. 11. 1973. V. 2.* V. 5. IX. 17. X. 24. 1974. VI. 25. 1975. IV. 7.* VII. 28.* X. 28.*
Andráshida	A	81.960	1973. V. 2.* V. 5. IX. 17.* 1974. VI. 25. 1975. IV. 7.* VII. 28.* X. 28.*
Pókaszepetk	P	63.300	1976. V. 16.
Zalaapáti	Z	22.810	1972. V. 26. X. 16. 1973. V. 7.* IX. 19.* X. 24. 1974. VI. 25. 1975. IV. 8.* VII. 28.* VIII. 25. X. 29.*
Fenékpuszta	F	0.000 0.345	1972. V. 26. X. 16. 1973. V. 7.* IX. 21.* X. 24. 1974. VI. 25. 1975. IV. 8.* VII. 29.* VIII. 25. X. 29.* 1976. III. 15. VII. 5. X. 4.

* Quantitative analyses.

$$J = \frac{H''}{\log_2 s}$$

where

J is the equitability,
H'' is the SHANNON—WEAVER diversity,
s is the number of taxa occurring in the sample.

We presented diversity, $\log_2 s$, equitability and number of taxa together, according to HAJDU's method (1976).
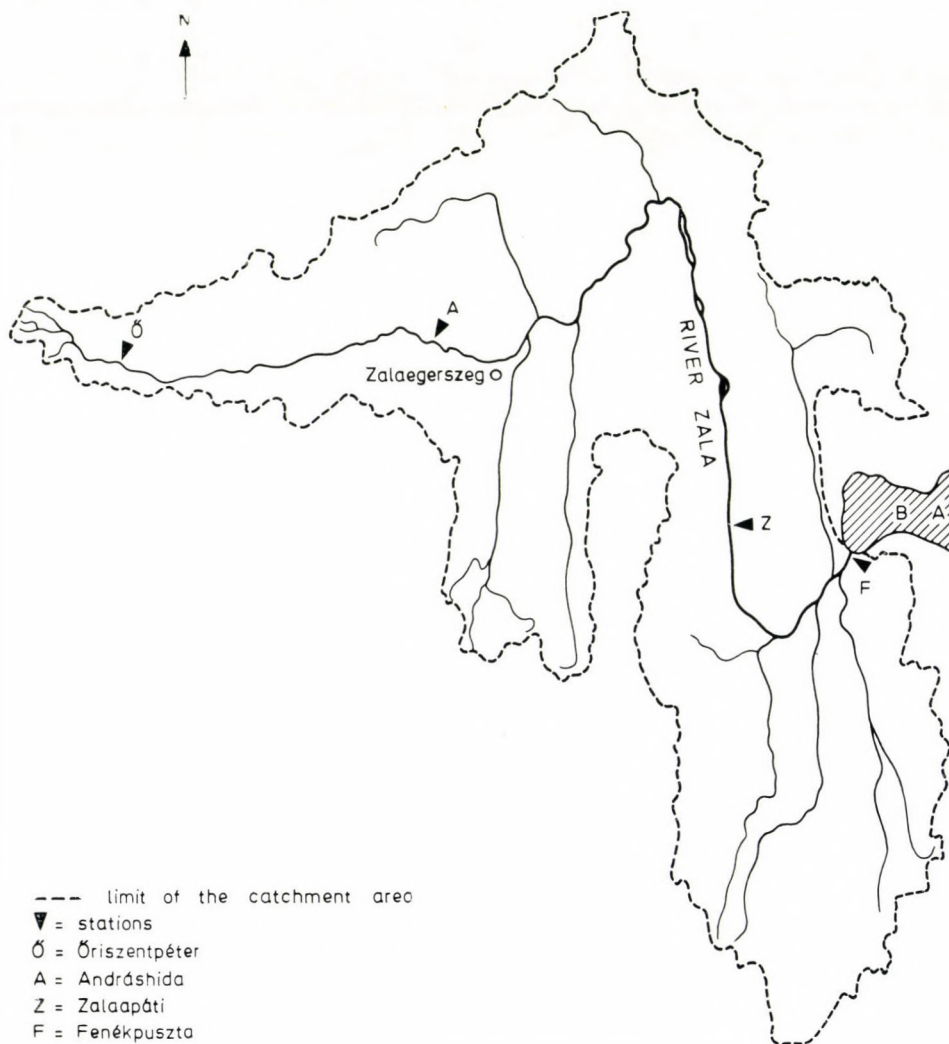
Fig. 1. Map of the Zala River with locations of sampling

Results and discussion

Enumeration of taxa examined

CYANOPHYTA

Chroococcales

1. *Microcystis aeruginosa* KÜTZ.
Diameter of cells: 3.0—5.0 μ.
F: 1975. IV. 8., VII. 29.

Hormogonales

2. *Aphanizomenon flos-aquae* (L.) RALFS
F: 1972. V. 26.
3. *Lyngbya epiphytica* HIERON.
Ő: 1975. X. 28.
Z: 1975. VII. 28.
4. *Lyngbya limnetica* LEMM.
Z: 1972. V. 26., 1975. X. 29.
5. *Oscillatoria limnetica* LEMM.
Width of trichomes: 1.5—2.0 μ. Length of cells: 5.0 μ.
F: 1972. X. 16.
6. *Oscillatoria limosa* AG.
Width of trichomes: 12.5—22.5 μ. Length of cells: 2.0—7.0 μ.
Ő: 1973. IX. 17., 1975. IV. 7.
F: 1972. V. 26., 1975. IV. 8.
7. *Oscillatoria planctonica* WOL.
Width of trichomes: 2.0—2.5 μ. Length of cells: 2.5—3.0 μ.
Ő: 1975. X. 28.
Z: 1975. X. 29.
F: 1975. VII. 29.
8. *Oscillatoria raciborskii* WOL.
Width of trichomes: 8.0 μ. Length of cells: 2.5 μ.
Z: 1972. V. 26.
9. *Oscillatoria sancta* (KÜTZ.) GOM.
Width of trichomes: 15.0 μ. Length of cells: 2.5—3.8 μ.
Z: 1972. V. 26.
10. *Oscillatoria tenuis* AG.
Width of trichomes: 7.5—12.5 μ. Length of cells: 1.8—5.0 μ.
Ő: 1973. IX. 17., 1975. IV. 7.
Z: 1972. V. 26.
F: 1972. V. 26., 1973. IX. 21.
11. *Romeria elegans* (KOCZW.) WOL.
Dimensions of cells: 4.0×1.5 μ.
A: 1973. IX. 17.

EUGLENOPHYTA

Euglenales

12. *Euglena acus* EHR.
Dimensions of cells: 130—132.5×10.0—12.0 μ. Paramylum: rodlike bodies, commonly ten, 8.5—14.0×2.0—3.0 μ in size.
A: 1973. V. 5.
Z: 1975. VII. 28.
F: 1972. X. 16., 1975. VII. 29.
13. *Euglena tripteris* (DUJ.) KLEBS
F: 1975. VII. 29.
14. *Phacus caudatus* HÜBN.
F: 1973. IX. 21.
15. *Phacus longicauda* (EHR.) DUJ.
Z: 1973. IX. 19.
F: 1972. V. 26.
16. *Phacus pyrum* (EHR.) STEIN
Dimension of cell: 30.0×15.0 μ.
F: 1973. V. 7.
17. *Phacus tortus* (LEMM.) SKV.
F: 1975. VII. 29.
18. *Trachelomonas similis* STOKES
Dimensions of lorica with the curved collar: 30.0—31.0×17.0—19.0 μ. Diameter of pore: 2.0 μ.
F: 1972. X. 16.
19. *Trachelomonas volvocina* EHR.
A: 1973. IX. 17.
Z: 1973. V. 7., 1975. X. 29.
F: 1973. IX. 21., 1975. X. 29.

CHRYSOPHYTA

Xanthophyceae

20. *Planctonema lauterbornii* SCHMIDLE
F: 1975. X. 29.

Chrysophyceae

21. *Anthophysa vegetans* (O.F.M.) STEIN
Ő: 1972. IX. 11., 1973. V. 2., V. 5., IX. 17., X. 24., 1974. VI. 25., 1975. IV. 7., VII. 28., X. 28.
A: 1973. V. 5., IX. 17., 1974. VI. 25., 1975. IV. 7., VII. 28.
P: 1976. VI. 16.
Z: 1972. V. 26., X. 16., 1973. V. 7., IX. 19., X. 24., 1974. VI. 25., 1975. IV. 8., VII. 28., VIII. 25., X. 29.
F: 1972. V. 26., X. 16., 1973. V. 7., IX. 21., X. 24., 1974. VI. 25., 1975. IV. 8., VII. 29., VIII. 25., X. 29.
22. *Dinobryon divergens* IMHOF
Ő: 1975. IV. 7.
F: 1975. VII. 29.

Bacillariophyceae

Centrales

23. *Cyclotella bodanica* EULENST.
Z: 1975. VII. 28.
24. *Cyclotella comta* (EHR.) KÜTZ.
Diameter of valve: 22.0—23.0 μ.

P: 1976. VI. 16.
Z: 1973. V. 7.
F: 1972. X. 16., 1973. X. 24.

25. *Cyclotella glomerata* BACHM.
Diameter of valve: 10.0 μ. Striae: 10/10 μ.
A: 1973. V. 2.
Z: 1973. V. 7.
F: 1973. V. 7., IX. 21.

26. *Cyclotella meneghiniana* KÜTZ. (Fig. 1–2)
Diameter of valve: 13.0–30.0 μ. Striae: 9–10/10 μ.
Ő: 1973. V. 2.
Z: 1973. V. 7., 1975. VII. 28., X. 29.
F: 1972. V. 26., 1973. V. 7., IX. 21., 1974. VI. 25., 1975. IV. 8., VII. 29., 1976. VII. 5.

27. *Cyclotella ocellata* PANT.
Diameter of valve: 19.0–22.5 μ. Striae: 9–10/10 μ.
Ő: 1973. V. 2.
A: 1973. IX. 17., 1975. VII. 28., X. 28.
Z: 1973. IX. 19., 1975. X. 29.
F: 1973. V. 7., IX. 21.

28. *Melosira granulata* (EHR.) RALFS
A: 1973. IX. 17., 1974. VI. 25.
Z: 1973. X. 24., 1974. VI. 25., 1975. VII. 28., X. 29.
F: 1972. X. 16., 1973. V. 7., 1974. VI. 25.

29. *Melosira granulata* (EHR.) RALFS var. *angustissima* MÜLL.
Diameter of valve: 4.0–4.5 μ. Length: 22.5 μ.
Ő: 1974. VI. 25.
A: 1975. X. 28.
Z: 1972. X. 16., 1975. X. 29.
F: 1973. V. 7., X. 24.

30. *Melosira granulata* (EHR.) RALFS var. *angustissima* MÜLL. f. spiralis MÜLL.
Diameter of valve: 4.0 μ.
Z: 1975. X. 29.
F: 1975. VII. 29.

31. *Melosira italica* (EHR.) KÜTZ.
Z: 1975. VII. 28.
F: 1973. IX. 21., 1975. VII. 29.

32. *Melosira islandica* O. MÜLL. ssp. *helvetica* O. MÜLL.
Diameter of valve: 5.0 μ. Length: 5.5 μ.
A: 1973. V. 2., IX. 17.
F: 1973. IX. 21.

33. *Melosira varians* C.A. AG.
Diameter of valve: 15.0–29.0 μ.
Ő: 1973. X. 24., 1974. VI. 25., 1975. VII. 28., X. 28.
A: 1974. VI. 25., 1975. VII. 28., X. 28.
Z: 1972. V. 26., X. 16., 1974. VI. 25., 1975. VII. 28., X. 29.
F: 1973. V. 7., IX. 21., 1974. VI. 25., 1975. VII. 29.

34. *Stephanodiscus hantzschii* GRUN.
Diameter of valve: 17.5 μ.
Z: 1973. V. 7., X. 24., 1975. VIII. 25.

Pennales

35. *Achnanthes gibberula* GRUN.
Z: 1973. V. 7.

36. *Achnanthes lanceolata* BRÉB.
Length: 20.0–21.0 μ. Width: 5.5–7.5 μ. Striae: 13/10 μ.
Ő: 1973. V. 2., 1975. VII. 28.
A: 1973. V. 5., IX. 17.
Z: 1972. V. 26., 1973. V. 7., IX. 19., X. 24.
F: 1973. V. 7., 1975. IV. 8., VII. 29., X. 29., 1976. III. 15.

37. *Achnanthes lanceolata* BRÉB. var. *rostrata* HUST.
Z: 1972. V. 26., 1973. X. 24.

38. *Achnanthes minutissima* KÜTZ.
Length: 12.5 μ. Width: 2.5 μ.
Ő: 1973. V. 5., X. 24., 1975. IV. 7.
Z: 1973. V. 7., X. 24.
F: 1973. V. 7.

39. *Amphora ovalis* KÜTZ.
Length: 37.5–38.0 μ. Width: 17.0–18.8 μ.
Ő: 1973. X. 24.
A: 1975. IV. 7., X. 28.
P: 1976. VI. 16.
F: 1972. V. 26., 1974. VI. 25.

40. *Anomoeoneis sphaerophora* (KÜTZ.) PFITZ.
F: 1973. X. 24.

41. *Asterionella formosa* HASS.
Length: 47.5 μ. Width: 3.0 μ.
Z: 1975. X. 29.
F: 1972. X. 16., 1975. X. 29.

42. *Caloneis amphisbaena* (BORY) CLEVE (Fig. 7)
Length: 69.0–80.0 μ. Width: 24.0–30.0 μ. Striae: 14–16/10 μ.
Ő: 1974. VI. 25.
A: 1973. V. 5., 1975. X. 28.
Z: 1972. X. 16.
F: 1976. III. 15.

43. *Caloneis bacillum* (GRUN.) MERESCHK.
Length: 24.0 μ. Width: 6.0 μ. Striae: 22/10 μ.
Ő: 1973. V. 5.

44. *Caloneis silicula* (EHR.) CLEVE (Fig. 6)
Length: 57.7–68.0 μ. Width: 14.0–15.0 μ. Striae: 16–18/10 μ.
Z: 1972. X. 16.
F: 1973. V. 7., 1976. III. 15.

45. *Ceratoneis arcus* KÜTZ.
Length: 47.5 μ. Width: 7.0 μ.
Ő: 1973. V. 5.

46. *Cocconeis pediculus* EHR.
Length: 26.5–50.0 μ. Width: 17.5–36.0 μ.
A: 1973. V. 5.
Z: 1972. V. 26., 1973. X. 24.
F: 1973. IX. 21., X. 24.

47. *Cocconeis placentula* EHR.
Length: 25.0–32.5 μ. Width: 15.0–22.5 μ.

Ő: 1973. V. 5.
A: 1975. VII. 28., X. 28.
Z: 1972. V. 26., X. 16., 1973. V. 7., IX. 19., X. 24., 1974. VI. 25., 1975. VII. 28.
F: 1972. V. 26., X. 16., 1973. V. 7., IX. 21., 1975. IV. 8., VII. 29.

48. Cocconeis placentula EHR. var. *euglypta* (EHR.) CLEVE
Length: 26.0—40.0 μ. Width: 16.0—25.0 μ. Punctae: 14/10 μ.
Z: 1972. V. 26., 1975. VIII. 25.

49. Cymatopleura elliptica (BRÉB.) W. SMITH var. *nobilis* (HANTZSCH) HUST.
A: 1975. VII. 28.

50. Cymatopleura solea (BRÉB.) W. SMITH
Length: 90.0—156 μ. Width: 22.5—42.0 μ. Costae: 7—8/10 μ.
Ő: 1973. V. 5., 1974. VI. 25.
A: 1973. V. 5., 1974. VI. 25.
Z: 1975. VII. 28., X. 29.
F: 1972. V. 26., 1973. V. 7., X. 24., 1974. VI. 25., 1975. VII. 29., 1976. III. 15.

51. Cymatopleura solea (BRÉB.) W. SMITH var. *regula* (EHR.) GRUN.
Length: 34.0 μ. Width: 9.0 μ. Costae: 7/10 μ.
Ő: 1973. V. 5.
F: 1972. X. 16.

52. Cymbella cistula (HEMPR.) GRUN.
F: 1972. X. 16.

53. Cymbella delicatula KÜTZ.
Length: 21.0 μ. Width: 5.0 μ. Striae: 16/10 μ.
Ő: 1972. IX. 11.

54. Cymbella lanceolata (EHR.) v. HEURCK
Length: 144—175 μ. Width: 25.6—44.0 μ.
F: 1972. V. 26., 1975. IV. 8.

55. Cymbella naviculiformis AUERSW.
Length: 35.0 μ. Width: 10.0 μ. Striae: 16/10 μ.
Ő: 1973. V. 2., V. 5

56. Cymbella prostrata (BERK.) CLEVE
Length: 22.5—85.0 μ. Width: 17.5—30.0 μ. Striae: 10/10 μ.
A: 1973. V. 5., IX. 17., 1975. IV. 7., X. 28.
Z: 1973. V. 7., IX. 19., X. 24., 1974. VI. 25., 1975. IV. 8., VII. 28.
F: 1975. IV. 8.

57. Cymbella sinuata GREG.
Z: 1975. VII. 28.

58. Cymbella ventricosa KÜTZ.
Length: 22.0—30.0 μ. Width: 6.0—10.0 μ. Striae: 12—13/10 μ.
Ő: 1972. IX. 11., 1975. VII. 28., X. 28.
A: 1973. V. 5., 1975. IV. 7., VII. 28., X. 28.
Z: 1972. V. 26., 1973. IX. 19.
F: 1972. X. 16., 1973. IX. 21.

59. Diatoma elongatum AG.
Length: 77.5 μ. Width: 5.0 μ. Costae: 7/10 μ.
Z: 1975. X. 29.
F: 1975. IV. 8.

60. Diatoma vulgare BORY
Length: 47.5 μ. Width: 12.5 μ. Costae: 7/10 μ.
F: 1972. V. 26., X. 16.

61. Diploneis ovalis (HILSE) CLEVE
Z: 1972. V. 26.

62. Epithemia sorex KÜTZ.
Length: 24.0—30.0 μ. Width: 9.0—10.0 μ. Areolae: 14/10 μ.
F: 1973. V. 7.

63. Epithemia zebra (EHR.) KÜTZ. var. *porcellus* (KÜTZ.) GRUN.
Length: 43.8 μ. Width: 10.0 μ.
F: 1973. V. 7.

64. Eunotia lunaris (EHR.) GRUN.
Length: 57.5 μ. Width: 5.0 μ.
F: 1973. V. 7.

65. Fragilaria capucina DESM.
Length: 37.5 μ. Width: 5.0 μ.
Ő: 1975. IV. 7.
A: 1973. V. 5.
F: 1972. V. 26., 1974. VI. 25., 1975. IV. 8.

66. Fragilaria construens (EHR.) GRUN.
Length: 31.0 μ. Width: 7.0—13.0 μ. Striae: 14/10 μ.
A: 1975. IV. 7.
F: 1972. X. 16., 1973. X. 24., 1975. VII. 29.

67. Fragilaria crotonensis KITTON
Length: 150 μ. Width: 7.5 μ.
F: 1973. V. 7.

68. Gomphonema acuminatum EHR.
Ő: 1975. VII. 28.

69. Gomphonema acuminatum EHR. var. *coronata* (EHR.) W. SMITH
Length: 50.0—84.0 μ. Width: 13.0—22.5 μ. Striae: 6—7/10 μ.
Ő: 1973. V. 5., 1975. VII. 28.
A: 1975. X. 28.
Z: 1972. V. 26.
F: 1972. X. 16.

70. Gomphonema angustatum (KÜTZ.) RABENH. var. *producta* GRUN.
Length: 22.5—31.0 μ. Width: 5.5—8.0 μ. Striae: 10/10 μ.
Ő: 1973. V. 5., 1975. VII. 28.
A: 1975. VII. 28.
F: 1974. VI. 25., 1975. VII. 29.

71. Gomphonema augur EHR.
Length: 30.0 μ. Width: 15.0 μ.
A: 1973. V. 2., IX. 17.
Z: 1975. VII. 28.
F: 1973. IX. 21., 1974. VI. 25., 1975. VII. 29.

72. Gomphonema constrictum EHR.
Length: 30.0—55.0 μ. Width: 12.0—20.0 μ. Striae: 8—10/10 μ.
Ő: 1973. V. 5., IX. 17., X. 24., 1975. VII. 28.
A: 1973. IX. 17., 1974. VI. 25., 1975. X. 28.
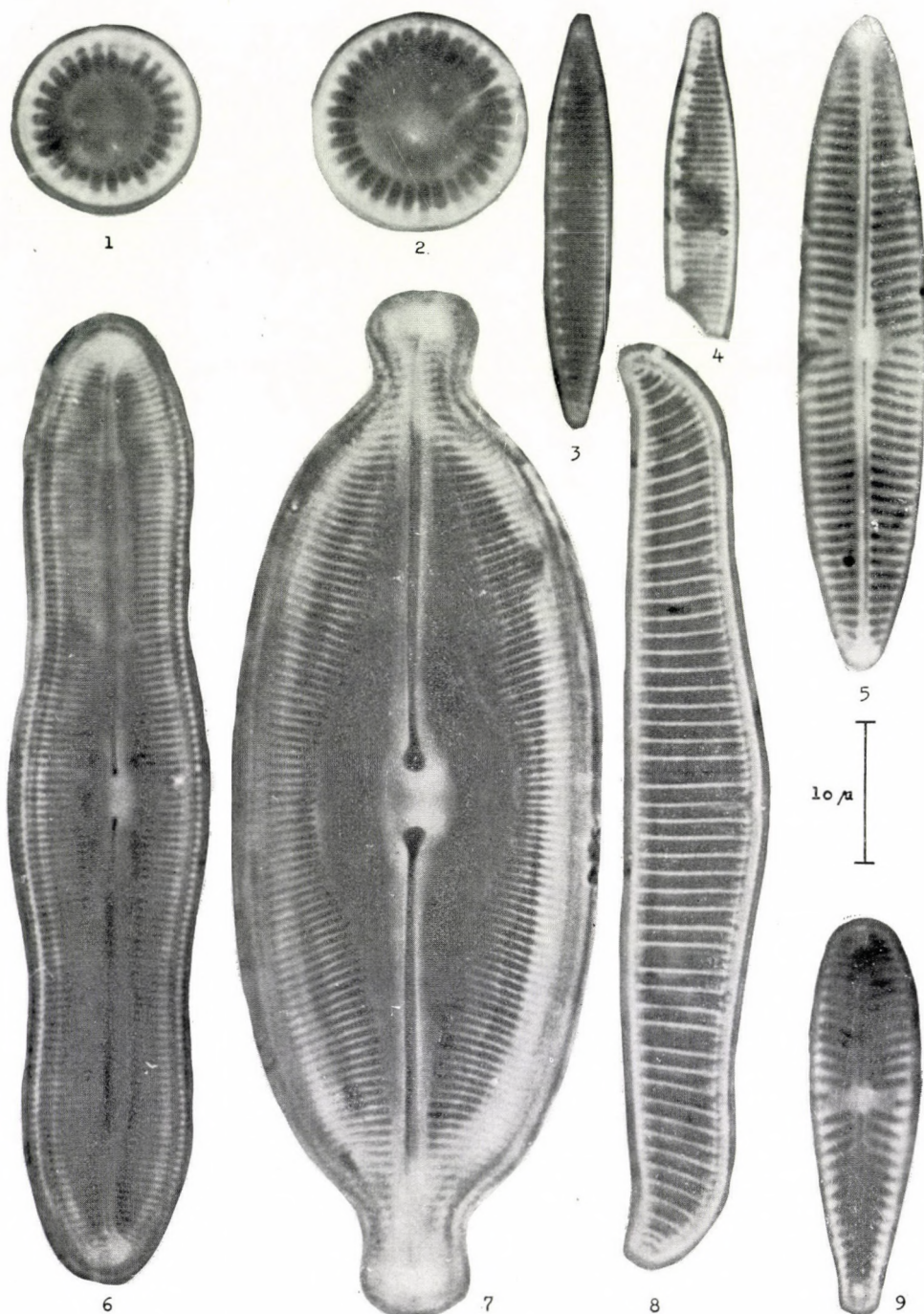
Plate I. 1–2: *Cyclotella meneghiniana* KÜTZ; 3–4: *Nitzschia amphibia* GRUN.; 5: *Navicula gracilis* EHR.; 6: *Caloneis silicula* (EHR.) CLEVE; 7: *Caloneis amphisbaena* (BORY) CLEVE 8: *Rhopalodia gibba* (EHR.) O. MÜLL.; 9: *Gomphonema olivaceum* (LYNGB.) KÜTZ.

Z: 1972. V. 26., 1973. X. 24., 1975. VII. 28.
F: 1972. V. 26., 1973. IX. 21., 1975. IV. 8., VII. 29.

73. *Gomphonema intricatum* KÜTZ.
Ő: 1973. V. 2.

74. *Gomphonema intricatum* KÜTZ. var. *vibrio* (EHR.) CLEVE
F: 1975. VII. 29.

75. *Gomphonema olivaceum* (LYNGB.) KÜTZ. (Fig. 9)
Length: 23.4—35.0 μ. Width: 7.4—10.0 μ. Striae: 10—12/10 μ.
Ő: 1973. V. 5.
A: 1973. IX. 17., 1975. VII. 28.
Z: 1972. V. 26., 1973. V. 7., IX. 19., 1975. IV. 8.
F: 1973. V. 7., IX. 21., X. 24., 1975. IV. 8., VII. 29., 1976. III. 15.

76. *Gomphonema parvulum* KÜTZ.
Length: 17.0—25.0 μ. Width: 5.0—10.0 μ. Striae: 12—16/10 μ.
Ő: 1972. IX. 11., 1973. IX. 17., X. 24., 1975. IV. 7., X. 28.
A: 1975. X. 28.
Z: 1973. IX. 19.
F: 1976. III. 15.

77. *Gyrosigma acuminatum* (KÜTZ.) RABENH.
Length: 110—115 μ. Width: 15.0 μ.
Ő: 1973. X. 24.
Z: 1972. V. 26.

78. *Gyrosigma attenuatum* (KÜTZ.) RABENH.
Length: 222—330 μ. Width: 25.0—27.5 μ.
Ő: 1973. V. 5.
Z: 1973. X. 24., 1975. IV. 8.
F: 1972. V. 26., 1973. X. 24.

79. *Gyrosigma scalproides* (RABENH.) CLEVE
Length: 47.5 μ. Width: 10.0 μ.
Ő: 1975. VII. 28.
A: 1975. VII. 28., X. 28.
Z: 1972. X. 16., 1973. IX. 19., 1975. X. 29.
F: 1975. IV. 8.

80. *Hantzschia amphioxys* (EHR.) GRUN.
Length: 35.0—37.5 μ. Width: 7.5 μ. Keel punctae: 8/10 μ.
Ő: 1975. IV. 7., X. 28.
A: 1973. V. 5., 1974. VI. 25., 1975. VII. 28.
Z: 1972. V. 26., 1973. X. 24.
F: 1975. VIII. 25.

81. *Mastogloia smithii* THWAIT.
Length: 62.5 μ. Width: 13.7 μ.
Z: 1972. V. 26.

82. *Meridion circulare* AG.
Length: 27.5—33.0 μ. Width: 6.5—12.5 μ. Striae: 13—15/10 μ.
Ő: 1975. IV. 7.
A: 1973. V. 2., 1975. IV. 7.
Z: 1973. V. 7.
F: 1973. V. 7., 1976. III. 15.

83. *Navicula cryptocephala* KÜTZ.
Length: 25.0—57.5 μ. Width: 8.0—15.0 μ.
Ő: 1972. IX. 11., 1973. V. 2., V. 5., 1975. IV. 7., VII. 28., X. 28.
A: 1973. V. 2., V. 5., IX. 17., 1974. VI. 25., 1975. IV. 7., VII. 28., X. 28.
Z: 1972. V. 26., X. 16., 1973. V. 7., IX. 19., X. 24., 1974. VI. 25., 1975. VII. 28., VIII. 25., X. 29.
F: 1972. V. 26., X. 16., 1973. V. 7., IX. 21., 1975. IV. 8.

84. *Navicula cryptocephala* KÜTZ. var. *veneta* (KÜTZ.) GRUN.
Ő: 1973. V. 2.
Z: 1973. IX. 19.
F: 1973. IX. 21.

85. *Navicula cuspidata* KÜTZ.
Length: 27.5 μ. Width: 12.5 μ. Striae: 13/10 μ.
A: 1975. VII. 28.
Z: 1972. V. 26., X. 16.
F: 1972. V. 26.

86. *Navicula dicephala* (EHR.) W. SMITH
F: 1973. X. 24.

87. *Navicula gastrum* EHR.
Length: 32.0 μ. Width: 15.0 μ
A: 1973. IX. 17.
Z: 1974. VI. 25.
F: 1973. X. 24., 1974. VI. 25.

88. *Navicula gracilis* EHR. (Fig. 5)
Length: 46.0—52.5 μ. Width: 9.0—12.5 μ. Striae: 11—12/10 μ.
Ő: 1972. IX. 11.
A: 1973. V. 5., IX. 17., 1974. VI. 25., 1975. IV. 7., VII. 28., X. 28.
Z: 1972. V. 26., X. 16., 1973. V. 7., IX. 19., X. 24., 1975. VIII. 25., X. 29.
F: 1972. X. 16., 1973. V. 7., X. 24., 1976. III. 15.

89. *Navicula hungarica* GRUN. var. *capitata* (EHR.) CLEVE
Length: 25.0—37.5 μ. Width: 10.0—12.5 μ. Striae: 5—7/10 μ.
Ő: 1975. X. 28.
A: 1973. IX. 17., 1974. VI. 25., 1975. VII. 28., X. 28.
Z: 1973. IX. 19., 1975. X. 29.
F: 1972. X. 16., 1973. V. 7., IX. 21., X. 24., 1975. IV. 8.

90. *Navicula menisculus* SCHUM.
A: 1975. IV. 7.

91. *Navicula placentula* (EHR.) GRUN.
A: 1975. IV. 7., X. 28.

92. *Navicula radiosa* KÜTZ.
Length: 37.5 μ. Width: 10.0 μ. Striae: 10—12/10 μ.
Ő: 1973. V. 2.
A: 1973. V. 5., 1974. VI. 25., 1975. IV. 7., X. 28.
Z: 1972. V. 26., 1973. V. 7., X. 24.
F: 1972. V. 26., X. 16., 1973. IX. 21.

93. *Navicula rhynchocephala* KÜTZ.
Length: 50.0—70.0 μ. Width: 12.5—15.0 μ. Striae: 8—9/10 μ.

Ő: 1973. V. 2., V. 5., IX. 17., X. 24., 1975. IV. 7.
A: 1973. V. 5., IX. 17., 1975. VII. 28.
Z: 1973. V. 7., IX. 19., X. 24.
F: 1972. V. 26., 1973. V. 7.

94. *Navicula tuscula* (EHR.) GRUN.
Ő: 1973. V. 5.

95. *Navicula viridula* KÜTZ.
Length: 41.0–50.0 μ. Width: 10.0–11.0 μ. Striae: 11–13/10 μ.
Ő: 1972. IX. 11., 1973. V. 2., V. 5., IX. 17., X. 24., 1974. VI. 25., 1975. IV. 7., X. 28.
A: 1973. V. 2., V. 5., IX. 17., 1974. VI. 25., 1975. IV. 7., VII. 28., X. 28.
Z: 1972. V. 26., X. 16., 1973. V. 7., IX. 19., X. 24., 1974. VI. 25., 1975. IV. 8., VII. 28., VIII. 25., X. 29.
F: 1972. V. 26., X. 16., 1973. V. 7., IX. 21., 1974. VI. 25., 1975. IV. 8., VII. 29., 1976. III. 15.

96. *Neidium dubium* (EHR.) CLEVE f. *constricta* HUST.
Ő: 1972. IX. 11.

97. *Neidium productum* (W. SMITH) CLEVE
Z: 1973. X. 24.

98. *Nitzschia acicularis* W. SMITH
Length: 65.0–128 μ. Width: 3.7–5.0 μ.
Ő: 1973. V. 2., V. 5., 1975. IV. 7., VII. 28., X. 28.
A: 1973. V. 2., V. 5., IX. 17., 1975. IV. 7., VII. 28., X. 28.
P: 1976. VI. 16.
Z: 1972. V. 26., X. 16., 1973. V. 7., IX. 19., 1975. VII. 28., VIII. 25., X. 29.
F: 1972. X. 16., 1973. V. 7., 1974. VI. 25., 1975. IV. 8., VII. 29., X. 29.

99. *Nitzschia acuta* HANTZSCH
Length: 87.0 μ. Width: 5.0 μ.
Ő: 1973. V. 5.
Z: 1973. V. 7.

100. *Nitzschia amphibia* GRUN. (Fig. 3–4)
A: 1973. V. 5.
Z: 1972. V. 26.
F: 1976. III. 15.

101. *Nitzschia angustata* (W. SMITH) GRUN.
Z: 1972. X. 16., 1973. V. 7.

102. *Nitzschia capitellata* HUST.
Length: 66.0–70.0 μ. Width: 6.0–8.0 μ. Keel punctae: 11/10 μ.
Ő: 1975. X. 28.
A: 1975. X. 28.
Z: 1973. V. 7., IX. 19.
F: 1973. IX. 21.

103. *Nitzschia commutata* GRUN.
Length: 85.0 μ. Width: 10.0 μ. Keel punctae: 6/10 μ.
F: 1975. VII. 29.

104. *Nitzschia dissipata* (KÜTZ.) GRUN.
Length: 16.5–35.0 μ. Width: 3.7–7.5 μ. Keel punctae: 5–6/10 μ.
Ő: 1973. V. 5.
A: 1975. X. 28.
Z: 1973. IX. 19.
F: 1973. V. 7., 1975. IV. 8.

105. *Nitzschia frustulum* (KÜTZ.) GRUN.
Length: 47.0 μ. Width: 5.0 μ. Keel punctae: 12/10 μ.
Ő: 1972. IX. 11.
Z: 1972. V. 26.

106. *Nitzschia holsatica* HUST.
Length: 52.5 μ. Width: 3.7 μ.
F: 1972. X. 16.

107. *Nitzschia kützingiana* HILSE
Length: 26.0 μ. Width: 3.5 μ. Keel punctae: 14/10 μ.
Z: 1972. V. 26., 1973. IX. 19.

108. *Nitzschia linearis* W. SMITH
Length: 100–160 μ. Width: 7.5–8.5 μ. Keel punctae: 8–12/10 μ.
Ő: 1972. IX. 11, 1973. V. 2., IX. 17., 1975. IV. 7., VII. 28., X. 28.
A: 1973. V. 5., IX. 17., 1974. VI. 25., 1975. IV. 7., VII. 28., X. 28.
Z: 1972. V. 26., X. 16., 1973. V. 7., IX. 19., X. 24., 1975. VII. 28., X. 29.
F: 1972. V. 26., X. 16., 1973. V. 7., IX. 21., X. 24., 1974. VI. 25., 1975. IV. 8., VII. 29., VIII. 25., X. 29.

109. *Nitzschia microcephala* GRUN.
Length: 22.5 μ. Width: 5.0 μ.
Z: 1975. IV. 8.

110. *Nitzschia palea* (KÜTZ.) W. SMITH
Length: 30.0–58.0 μ. Width: 5.0–7.0 μ. Keel punctae: 10–12/10 μ.
Ő: 1973. V. 2., V. 5., IX. 17., 1974. VI. 25., 1975. IV. 7., VII. 28., X. 28.
A: 1973. V. 2., V. 5., IX. 17., 1974. VI. 25., 1975. IV. 7., VII. 28., X. 28.
P: 1976. VI. 16.
Z: 1972. V. 26., X. 16., 1973. V. 7., IX. 19., X. 24., 1975. IV. 8., VII. 28., X. 29.
F: 1972. X. 16., 1973. V. 7., IX. 21., 1974. VI. 25., 1975. IV. 8., VII. 29., X. 29.

111. *Nitzschia parvula* LEV.
Ő: 1975. IV. 7.
Z: 1972. V. 26.
F: 1972. V. 26., X. 16.

112. *Nitzschia recta* HANTZSCH
Length: 60.0 μ. Width: 5.0 μ.
Z: 1973. V. 7.
F: 1972. X. 16.

113. *Nitzschia romana* GRUN.
Length: 37.5 μ. Width: 5.0 μ.
Ő: 1973. IX. 17.

114. *Nitzschia sigmoidea* (EHR.) W. SMITH
Length: 320–480 μ. Width: 9.6–30.0 μ. Keel punctae: 5–7/10 μ.
A: 1973. V. 5., 1975. X. 28.
Z: 1972. V. 26., 1975. IV. 8., VII. 28.
F: 1972. V. 26., 1973. V. 7., X. 24., 1974. VI. 25., 1975. IV. 8.

115. *Nitzschia stagnorum* RABENH.

Length: 90.0 μ. Width: 10.0 μ. Keel punctae: 6—7/10 μ.
A: 1975. X. 28.
Z: 1973. IX. 19., 1975. X. 29.
F: 1973. IX. 21., 1975. VII. 29.

116. *Nitzschia sublinearis* HUST.
Ő: 1975. IV. 7.
Z: 1972. V. 26.
F: 1973. IX. 21.

117. *Nitzschia tryblionella* HANTZSCH var. *victoriae* GRUN.
Length: 29.0—48.0 μ. Width: 16.0—24.0 μ. Keel punctae: 7—8/10 μ.
F: 1973. IX. 21., 1975. VIII. 25.

118. *Nitzschia vermicularis* (KÜTZ.) GRUN.
Length: 130 μ. Width: 6.5—7.5 μ. Keel punctae: 8/10 μ.
A: 1973. IX. 17.
F: 1972. V. 26.

119. *Pinnularia borealis* EHR.
A: 1973. V. 2.

120. *Pinnularia interrupta* W. SMITH
A: 1975. IV. 7.

121. *Pinnularia maior* KÜTZ.
F: 1973. V. 7.

122. *Pinnularia microstauron* (EHR.) CLEVE
Ő: 1973. V. 2., V. 5., 1975. IV. 7.

123. *Pinnularia microstauron* (EHR.) CLEVE var. *brébissonii* (KÜTZ.) HUST.
Length: 41.0 μ. Width: 10.0 μ. Striae: 13/10 μ.
A: 1973. V. 5.

124. *Pinnularia microstauron* (EHR.) CLEVE f. *biundulata* O. MÜLL.
Ő: 1973. V. 5.

125. *Pinnularia molaris* GRUN.
F: 1975. VII. 29.

126. *Rhoicosphaenia curvata* (KÜTZ.) GRUN.
Length: 30.0—37.0 μ. Width: 12.5 μ. Striae: 6/10 μ.
A: 1973. V. 5.
Z: 1975. X. 29.
F: 1972. X. 16., 1975. VII. 29.

127. *Rhopalodia gibba* (EHR.) O. MÜLL. (Fig. 8)
Length: 64.8 μ. Width: 8.5 μ. Costae: 7—8/10 μ.
F: 1976. III. 15.

128. *Rhopalodia gibba* (EHR.) O. MÜLL. var. *ventricosa* (EHR.) GRUN.
F: 1975. VII. 29.

129. *Stauroneis anceps* EHR.
Z: 1972. V. 26.

130. *Stauroneis anceps* EHR. f. *gracilis* (EHR.) CLEVE
Length: 53.7 μ. Width: 10.0 μ.
Ő: 1973. V. 5.

131. *Stauroneis phoenicenteron* EHR.
Ő: 1973. V. 5.

132. *Stauroneis smithii* GRUN.
Length: 22.5 μ. Width: 7.5 μ.
Ő: 1975. IV. 7.

133. *Surirella angustata* KÜTZ.
Length: 37.5 μ. Width: 7.5 μ.
Ő: 1973. V. 5.
A: 1975. VII. 28., X. 28.

134. *Surirella biseriata* BRÉB.
Length: 250 μ. Width: 80.0 μ.
F: 1972. V. 26.

135. *Surirella linearis* W. SMITH
Length: 90.0 μ. Width: 37.5 μ.
Z: 1972. V. 26.
F: 1973. X. 24.

136. *Surirella ovalis* BRÉB.
Z: 1972. V. 26., 1973. V. 7.

137. *Surirella ovata* KÜTZ.
Length: 23.5—25.0 μ. Width: 11.0—12.5 μ.
Ő: 1972. IX. 11., 1973. V. 2., V. 5., 1975. IV. 7., VII. 28., X. 28.
A: 1973. V. 2., V. 5., 1974. VI. 25., 1975. IV. 7., VII. 28., X. 28.
Z: 1973. V. 7., IX. 19., 1975. IV. 8., VIII. 25., X. 29.
F: 1973. V. 7., IX. 21., X. 24.

138. *Surirella ovata* KÜTZ. var. *pinnata* (W. SMITH) HUST.
Length: 28.0 μ. Width: 9.0 μ.
Ő: 1973. V. 5., 1975. IV. 7., VII. 28.
A: 1975. X. 28.
Z: 1972. V. 26.

139. *Surirella robusta* EHR. var. *splendida* (EHR.) v. HEURCK
Length: 100—125 μ. Width: 60.0—70.0 μ.
Ő: 1973. V. 5.
A: 1973. IX. 17.
Z: 1972. V. 26.
F: 1972. V. 26., 1975. VII. 29.

140. *Synedra acus* KÜTZ.
Length: 180 μ. Width: 4.5 μ.
Z: 1975. X. 29.
F: 1972. V. 26., X. 16., 1973. V. 7., 1975. X. 29.

141. *Synedra acus* KÜTZ. var. *angustissima* GRUN.
Z: 1973. V. 7.

142. *Synedra capitata* EHR.
F: 1972. V. 26., 1973. V. 7.

143. *Synedra ulna* (NITZSCH) EHR.
Length: 100—318 μ. Width: 4.5—8.0 μ. Striae: 8/10 μ.
Ő: 1972. IX. 11., 1973. V. 2., V. 5., IX. 17., X. 24., 1974. VI. 25., 1975. IV. 7., VII. 28.
A: 1973. V. 2., V. 5., 1974. VI. 25., 1975. IV. 7., VII. 28.
Z: 1972. V. 26., X. 16., 1973. V. 7., IX. 19., X. 24., 1975. IV. 8., VII. 28.
F: 1972. V. 26., 1973. V. 7., X. 24., 1974. VI. 25., 1975. IV. 8., VII. 29.

144. *Synedra ulna* (NITZSCH) EHR. var. *biceps* (KÜTZ.) SCHÖNF.
Length: 202 μ. Width: 7.5 μ.
Z: 1975. IV. 8.

145. *Synedra ulna* (NITZSCH) EHR. var. *oxyrhynchus* (KÜTZ.) v. HEURCK

Length: 50.0–68.8 μ. Width: 4.5–8.7 μ.
Ő: 1975. VII. 28.
A: 1975. VII. 28.
Z: 1973. V. 7.
F: 1973. V. 7., 1974. VI. 25.

146. Tabellaria fenestrata (LYNGB.) KÜTZ.
Length: 72.5 μ.
Ő: 1975. IV. 7.
A: 1973. V. 5.

147. Tabellaria flocculosa (ROTH) KÜTZ.
Length: 25.0–28.0 μ. Width: 3.0–5.0 μ.
Striae: 18/10 μ.
Ő: 1975. IV. 7., VII. 28.
A: 1973. V. 5.

PYRROPHYTA

Cryptophyceae

148. Cryptomonas erosa EHR.
F: 1975. VII. 29., X. 29.

CHLOROPHYTA

Chlorophyceae

Volvocales

149. Chlamydomonas simplex PASCH.
F: 1973. IX. 21.

150. Eudorina elegans EHR.
Ő: 1973. IX. 17.

151. Pandorina morum (MÜLL.) BORY
Ő: 1973. IX. 17.
A: 1973. IX. 17.
Z: 1972. X. 16.

Chlorococcales

152. Actinastrum hantzschii LAGERH.
Dimensions of cells: 12.5×2.5 μ.
Z: 1975. VII. 28.
F: 1975. VII. 29.

153. Ankistrodemus convolutus CORDA
Z: 1972. X. 16., 1975. VIII. 25.
F: 1972. X. 16., 1975. VII. 29., X. 29.

154. Ankistrodesmus falcatus (CORDA) RALFS
F: 1974. VI. 25.

155. Ankistrodesmus falcatus (CORDA) RALFS var. *acicularis* (A. BR.) G. S. WEST
F: 1972. X. 16.

156. Ankistrodesmus falcatus (CORDA) RALFS var. *spirilliformis* G. S. WEST
A: 1973. IX. 17., 1975. VII. 28.
Z: 1975. VII. 28.
F: 1975. VII. 29., X. 29.

157. Ankistrodesmus setigerus (SCHRÖD.) G. S. WEST
F: 1972. X. 16., 1973. V. 7., 1975. VII. 29.

158. Chodatella quadriseta LEMM.
F: 1975. VII. 29.

159. Coelastrum microporum NAEG.
A: 1973. IX. 17.
Z: 1972. X. 16., 1975. VII. 28., X. 29.
F: 1972. X. 16., 1975. VIII. 25., X. 29.

160. Crucigenia apiculata (LEMM.) SCHMIDLE (Fig. 10)
Coenobia of four cells. Dimensions of cells: 5.5–7.0×4.5 μ.
Ő: 1974. VI. 25.
F: 1974. VI. 25.

161. Crucigenia fenestrata SCHMIDLE
A: 1973. IX. 17.
Z: 1972. X. 16., 1973. IX. 19., 1975. VII. 28., VIII. 25., X. 29.
F: 1972. X. 16., 1973. V. 7., 1975. VII. 29., X. 29.

162. Crucigenia quadrata MORREN (Fig. 11)
Coenobia of four cells. Dimensions of cells: 5.5–6.5×5.0 μ.
Z: 1973. IX. 19.
F: 1972. X. 16., 1974. VI. 25., 1975. X. 29.

163. Crucigenia tetrapedia (KIRCHN.) W. et W. (Fig. 12)
Coenobia of four cells. Dimensions of cells: 7.5–7.7×5.0 μ.
A: 1973. IX. 17.
Z: 1975. VII. 28.
F: 1973. IX. 17., 1974. VI. 25.

164. Dictyosphaerium pulchellum WOOD
Z: 1975. VII. 28.
F: 1972. X. 16., 1975. X. 29.

165. Kirchneriella lunaris (KIRCHN.) MOEB.
A: 1973. IX. 17.
Z: 1975. VII. 28.
F: 1972. X. 16., 1973. V. 7., IX. 21., 1975. X. 29.

166. Kirchneriella obesa (W. WEST) SCHMIDLE
A: 1973. IX. 17., 1975. X. 28.
Z: 1973. IX. 19., 1975. VIII. 25.
F: 1975. X. 29.

167. Nephrochlamys subsolitaria (G. S. WEST.) KORSH.
Z: 1973. IX. 19.

168. Pediastrum boryanum (TURP.) MENEGH.
Z: 1972. V. 26., X. 16., 1975. VII. 28.
F: 1972. X. 16., 1974. VI. 25.

169. Pediastrum duplex MEYEN
F: 1972. X. 16.

170. Pediastrum tetras (EHR.) RALFS
F: 1972. X. 16.

171. Scenedesmus acuminatus (LAGERH.) CHOD. Coenobia of four cells. Dimensions of cells: 25–30.5×5–6.5 μ.
A: 1974. VI. 25.
Z: 1975. VII. 28.
F: 1972. X. 16., 1975. VII. 29., X. 29.

172. Scenedesmus acuminatus (LAGERH.) CHOD.
var. *elongatus* G. M. SMITH.
F: 1975. X. 29.

173. Scenedesmus anomalus (G. M. SMITH) TIFF. (Fig. 14)
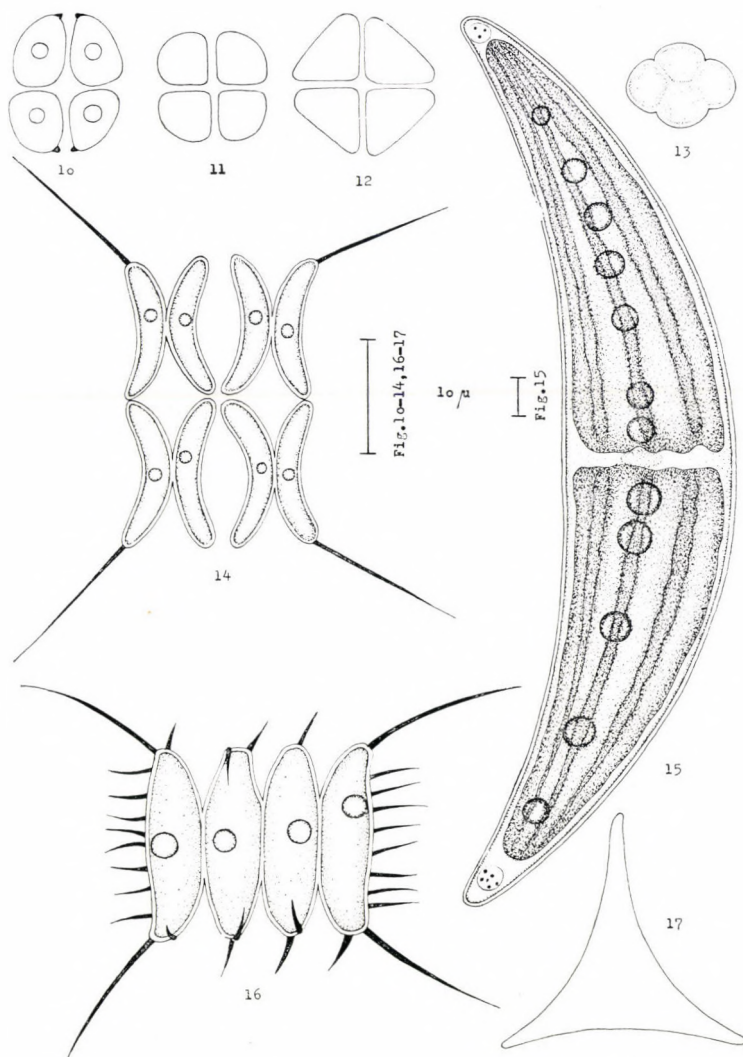
Plate II. 10: *Crucigenia apiculata* (LEMM.) SCHMIDLE; 11: *Crucigenia quadrata* MORREN; 12: *Crucigenia tetrapedia* (KIRCHN.) W. et W.; 13: *Tetrastrum glabrum* (ROLL) AHLSTR. et TIFF.; 14: *Scenedesmus anomalus* (G. M. SMITH) TIFF.; 15: *Closterium moniliferum* (BORY) EHR.; 16: *Scenedesmus rostrato-spinosus* CHOD. var. *serrato-pectinatus* CHOD.; 17: *Tetraëdron muticum* (A. BR.) HANSG.
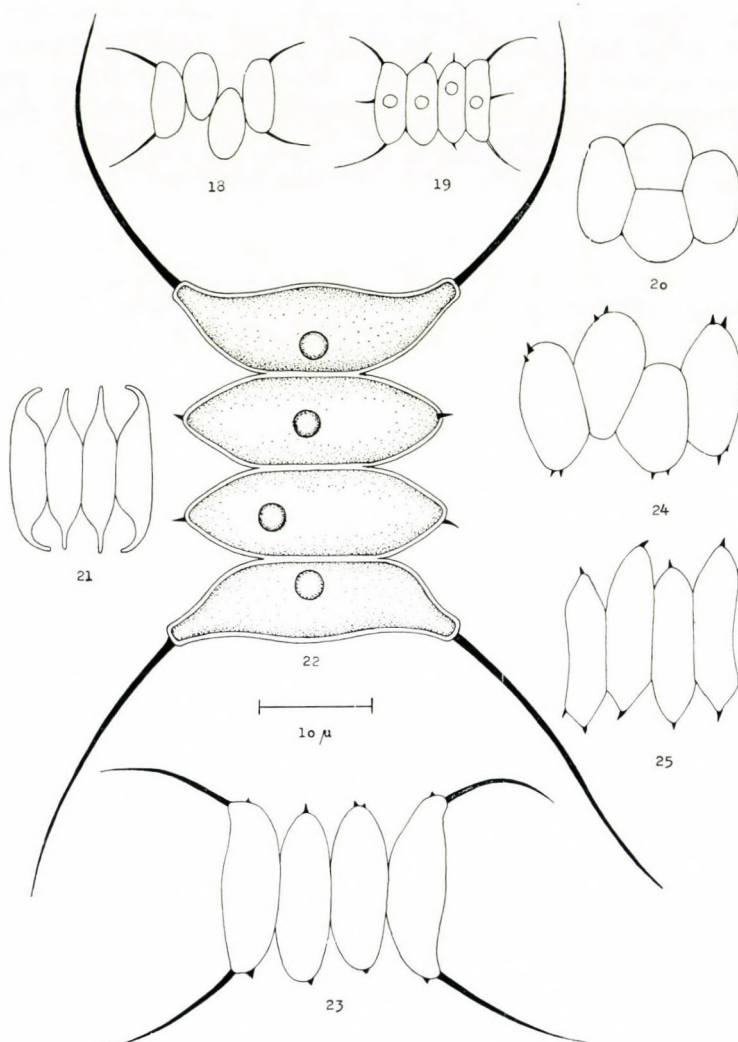
Plate III. 18: *Scenedesmus intermedius* CHOD.; 19: *Scenedesmus spinosus* CHOD.; 20: *Scenedesmus ecornis* (RALFS) CHOD. var. *disciformis* CHOD.; 21: *Scenedesmus coartatus* HORTOB.; 22—23: *Scenedesmus opoliensis* P. RICHT.; 24: *Scenedesmus denticulatus* LAGERH.; 25: *Scenedesmus denticulatus* LAGERH. var. *linearis* HANSG.

Coenobia of eight cells. Dimensions of cells: 12.5—13.0×2.5—3.0 μ. There are straight spines only on the free poles of outer cells, their lengths varies from 13.0 to 14.0 μ.
F: 1976. X. 4.

174. Scenedesmus coartatus HORTOB. (Fig. 21)
Coenobia of four cells. Dimensions of cells: 12.5—15.0×3.0—3.5 μ.
F: 1972. X. 16., 1975. VII. 29.

175. Scenedesmus denticulatus LAGERH. (Fig. 24)
Coenobia of four cells. Dimensions of cells: 10.0—12.0×4.5—6.0 μ.
F: 1972. X. 16., 1975. VII. 29., X. 29.

176. Scenedesmus denticulatus LAGERH. var. *linearis* HANSG. (Fig. 25)
Coenobia of four cells. Dimensions of cells: 14.0—15.0×3.5—4.0 μ.
F: 1972. X. 16.

177. Scenedesmus ecornis (RALFS) CHOD.
Z: 1973. IX. 19., 1975. X. 29.
F: 1972. X. 16., 1975. X. 29.

178. Scenedesmus ecornis (RALFS) CHOD. var. *disciformis* CHOD. (Fig. 20)
Coenobia of four cells. Dimensions of cells: 5.0—9.4×3.0—6.0 μ.
F: 1972. X. 16., 1973. IX. 21., 1975. VIII. 25., X. 29.

179. Scenedesmus granulatus W. et W.
Z: 1975. X. 29.
F: 1975. VII. 29.

180. Scenedesmus intermedius CHOD. (Fig. 18)
Coenobia of four cells. Dimensions of cells: 6.0—7.0×2.5—3.0 μ. Length of spines: 4.0—5.0 μ.
Z: 1975. VII. 28., VIII. 25.

181. Scenedesmus opoliensis P. RICHT. (Fig. 22—23)
Coenobia of four cells. Dimensions of cells: 14.5—26.0×4.5—8.5 μ. Length of spines: 9.5—29.5 μ.
F: 1974. VI. 25., 1975. VIII. 25., 1976. X. 4.

182. Scenedesmus quadricauda (TURP.) BRÉB.
A: 1973. IX. 17., 1975. IV. 7.
Z: 1972. X. 16., 1973. V. 7., IX. 21., 1975. IV. 8., VII. 29., X. 29.

183. Scenedesmus rostrato-spinosus CHOD. var. *serrato-pectinatus* CHOD. (Fig. 16)
Coenobia of four cells. Dimensions of cells: 17.0×5.0 μ. Length of the short and the long spines: 1.5—4.5 μ and 13.5—14.5 μ respectively.
P: 1976. VI. 16.

184. Scenedesmus spinosus CHOD. (Fig. 19)
Coenobia of four cells. Dimensions of cells: 7.5—11.0×2.5—3.0 μ. Length of spines: 0.5—5.0 μ.
Ő: 1974. VI. 25.
A: 1973. IX. 17.
Z: 1974. VI. 25.
F: 1972. X. 16., 1974. VI. 25., 1975. IV. 8., X. 29.

185. Tetraëdron caudatum (CORDA) HANSG. var. *incisum* LAGERH.
F: 1973. IX. 21.

186. Tetraëdron muticum (A. BR.) HANSG. (Fig. 17)
Length of a side: 22.0—23.0 μ.
A: 1973. IX. 18.

187. Tetrastrum glabrum (ROLL) AHLSTR. et TIFF. (Fig. 13)
Coenobia of four cells. Dimensions of cells: 4.5—5.0×3.5—4.0 μ.
F: 1972. X. 16., 1975. VIII. 25.

188. Tetrastrum staurogeniaeforme (SCHRÖD.) LEMM.
Z: 1975. VII. 28., VIII. 25.
F: 1975. IV. 8., X. 29.

Conjugatophyceae

Desmidiales

189. Closterium aciculare WEST
F: 1972. X. 16., 1974. VI. 25., 1975. X. 29.

190. Closterium moniliferum (BORY) EHR. (Fig. 15)
Dimension of cell: 240×46 μ.
F: 1974. VI. 25.

191. Staurastrum paradoxum MEYEN
A: 1973. IX. 17.
Z: 1975. VII. 28.
F: 1972. X. 16.

The quantitative ecology of the phytoplankton

The number of taxa which occurred in the whole period of investigations in the individual sampling sites, and the distribution of the taxa numbers among the various taxonomical groups, are shown in Table 2. In all the experimental stations, the highest number of taxa is represented by *Bacillariophyceae*, the next in order is *Chlorococcales* — with the exception of Őriszentpéter. The taxon number of the order of *Chlorococcales* increases in the direction from

Őriszentpéter towards Fenékpuszta; this increase also prevails in the case of diatoms, after a smaller fall at Andráshida. The taxon number of plankton algae observed at the individual sampling sites, in the direction from the origin of the river towards its mouth, also increases. This is especially remarkable if a comparison is made between the two upper sampling sites (Őriszenpéter and

Table 2

Number of taxa observed at different stations

Systematic groups	Stations			
	Ő	A	Z	F
Cyanophyta	4	1	6	6
Euglenophyta	0	2	3	8
Xanthophyceae	0	0	0	1
Chrysophyceae	2	1	1	2
Bacillariophyceae	61	57	76	82
Cryptophyceae	0	0	0	1
Volvocales	2	1	1	1
Chlorococcales	2	10	19	33
Desmidiales	0	1	1	3
Number of algal taxa	71	73	107	137

Andráshida) and the two stations of the lower reach (Zalaapáti, Fenékpuszta) (Fig. 2). The number of taxa belonging in the order *Chlorococcales* increases at a much greater rate in the direction towards the mouth than that of the diatoms, which results in the increase of the ratio number between the *Chlorococcales* and *Bacillariophyceae* taxa (Fig. 3). The greater proportion of the unicellular green algae in both the taxon number and the composition of the phytoplankton periodically becomes especially pronounced in the area of Fenékpuszta. Such a state developed there on October 29, 1975, when the *Chlorococcales* : *Bacillariophyceae* taxon ratio increased to 3.14; 59.1% of the phytoplankton consisted of unicellular green algae, 11.9% of diatoms. These changes can be brought into correlation with the decrease in the flow velocity and with the increase in the plant nutrient content of the water below Zalaegerszeg, but the direct effect of the marsh waters flowing into the river at the lower reach cannot be left out of consideration. This indicated by the appearance of characteristic green algae formations like, for example, *Scenedesmus coartatus* Hortob., at Fenékpuszta.

The composition of the phytoplankton of the river Zala is shown in Table 3.

The dominance of *Chrysophyta* is characteristic of the phytoplankton of the river. In the course of our further analysis we exclude the *Chlorococcales* dominance which occurs at Fenékpuszta only rarely and simultaneously with the temporary stagnation of the water.

The ratio of *Chrysophyta* in the composition of phytoplankton is 81.0—100.0%, mostly above 90%, its minimum is at Fenékpuszta in all of the experimental periods. 49.1—98% of the phytoplankton consist of diatoms which
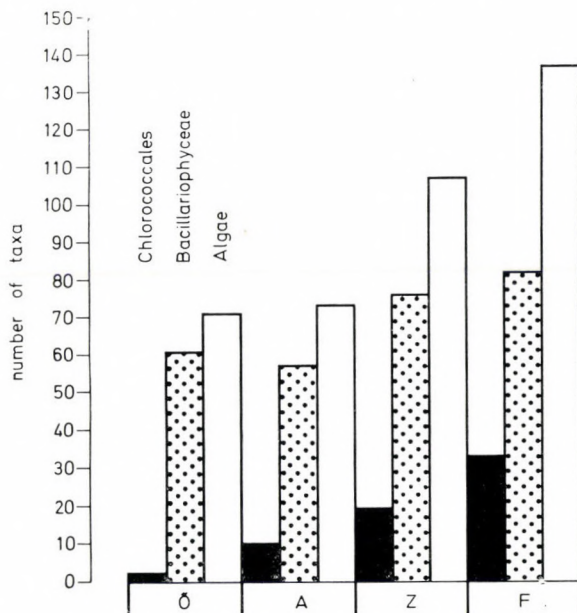
Fig. 2. Number of taxa at different stations
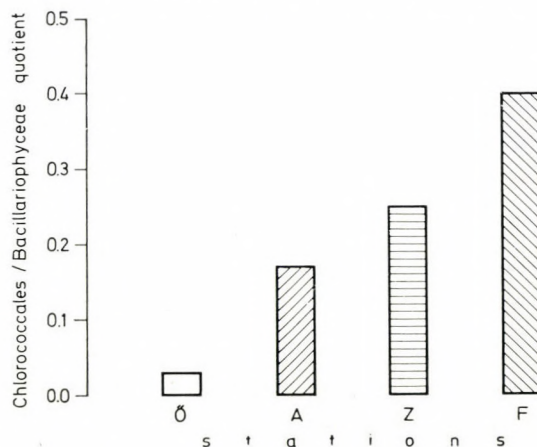
Fig. 3. Chlorococcales: Bacillariophyceae quotient on the basis of all taxa observed

Table 3

Distribution of phytoplankton algae

Systematic groups	1973. V. 2–7.				1973. IX. 17–21.		
	Ő	A	Z	F	A	Z	F
Cyanophyta	0	0	0	0	0.4	0	0.8
Euglenophyta	3.8	0	4.6	3.6	2.9	1.3	5.1
Xanthophyceae	0.5	0	0	0	0	0	0
Chrysophyceae	20.8	0	11.9	0	0	0.6	9.2
Bacillariophyceae	72.6	97.4	80.9	87.7	90.5	90.3	73.1
Cryptophyceae	0.9	2.2	2.6	4.6	0	0	1.7
Volvocales	0.9	0	0	0.5	2.1	0.6	4.2
Chlorococcales	0	0.4	0	3.6	3.3	7.2	5.9
Desmidiales	0.5	0	0	0	0.8	0	0
	100.0	100.0	100.0	100.0	100.0	100.0	100.0

represent the phylum *Chrysophyta* in the greatest proportion, sometimes exclusively. Changes in their proportion is not related to either the sampling sites or the sampling periods, while on the other hand it is in a reversed proportion with the ratio of *Chrysophyceae* (Fig. 4). The increase in the proportion of *Chrysophyceae*, which is almost exclusively represented by *Anthophysa vegetans* (O. F. M.) STEIN, is accompanied by the decrease in the proportion of diatoms, independently of the site and the time of sampling. The appearance of *A. vegetans* and the change in its proportion cannot be brought into relation
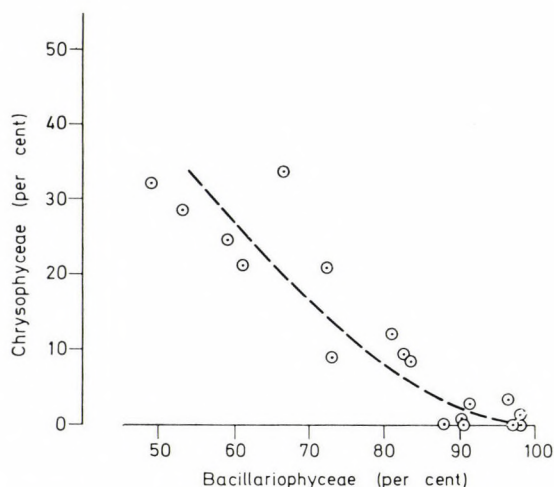
Fig. 4. Relation between the relative abundance of *Bacillariophyceae* and *Chrysophyceae*

among systematic groups in per cent

1975. IV. 7–8.				1975. VII. 28–29.				1975. X. 28–29.			
Ő	A	Z	F	Ő	A	Z	F	Ő	A	Z	F
0	0	0	0.9	0	0	1.2	0.9	12.7	0.9	0.9	3.2
2.3	0.3	0	6.0	0	1.4	3.6	5.3	1.0	0	4.7	9.6
0	0	0	0	0	0	0	0	0	0	0	2.2
5.8	1.6	3.5	9.5	33.6	8.2	24.4	31.9	28.5	0	21.2	8.6
91.3	97.8	96.5	82.3	66.4	83.5	58.9	49.1	52.9	98.3	60.9	11.9
0.6	0	0	0	0	1.4	1.2	5.3	3.9	0	9.0	3.2
0	0	0	0	0	1.4	0.6	0.4	1.0	0.4	0	1.1
0	0.3	0	1.3	0	4.1	9.5	7.1	0	0.4	3.3	59.1
0	0	0	0	0	0	0.6	0	0	0	0	1.1
100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

with any of the other parameters which were measured, calculated, and given in the present paper.

The algae belonging to the other taxonomical groups usually play a subordinated role in the composition of the phytoplankton, or they are missing from the composition. Among these, the plankton algae belonging in the *Chrysophyceae* occur at Őriszentpéter and Zalaapáti, while *Euglenophyta* and *Chlorococcales* at Fenékpuszta, in all the periods of sampling.

Figure 5, which was drawn on the basis of the average data from the period between May 1973 and July 1975, shows the changes in percentage ratio of the plankton algae belonging to the *Chrysophyta* and other groups along the river. From Őriszentpéter towards Fenékpuszta, the proportion of *Chrysophyta*, mainly the diatoms in the composition of the phytoplankton gradually decreases, and the proportion of plankton algae belonging in the other taxonomical groups increases. This reflects the process of the Zala becoming a stagnant water, which is especially pronounced at Fenékpuszta, where the constant presence of plankton algae belonging to the *Euglenophyta* and *Chlorococcales* is also an indication of the above statement.

The changes in diversity, $\log_2 s$, equitability and number of taxa are shown in Fig. 6. Besides these parameters, the total algal counts and the quantity of chlorophyll-a to be found in a unit volume of water are given in Table 4.

The value of diversity is 2.86—4.06 at Őriszentpéter, 2.29—4.37 at Andráshida, 1.69—4.41 at Zalaapáti, 3.69—4.92 at Fenékpuszta; on an average these values in the same order are 3.53, 3.01, 3.56 and 4.37. The values, after a smaller fall at Andráshida, increase in the direction of Fenékpuszta. Consid-

Table 4

Number of taxa(s), diversity (H″), log₂s, equitability (J),

Time	1973. V. 2–7.				1973. IX. 17–21.		
Station	Ő	A	Z	F	A	Z	F
Number of taxa (*s*)	30	17	25	42	33	40	47
Diversity (*H″*)	3.60	2.29	3.59	4.26	3.04	4.38	4.92
$\log_2 s$	4.91	4.09	4.64	5.39	5.04	5.32	5.56
Equitability (*J*)	0.73	0.56	0.77	0.79	0.60	0.82	0.89
Total algal counts ($10^6 \times$ ind./l)	—	—	—	—	—	—	—
Chlorophyll-a content (mg/m^3)	—	—	—	—	—	—	—

ering the various periods, this tendency does not prevail consistently. However, the maximum of diversity, with the exception of one period, was always measured at Fenékpuszta.

In April, 1975, the value of diversity and equitability considerably decreased from Őriszentpéter to Zalaapáti, then it rose again at Fenékpuszta, but it did not reach that measured at Őriszentpéter. This change is in close correlation with that occurring in the proportion of *Navicula viridula* KÜTZ., whose ratio in the phytoplankton composition is 1.2, 56.3, 76.5 and 34.5 per cent, downriver from Őriszentpéter towards Fenékpuszta. *N. viridula* becoming dominant is manifest also from the fall in equitability to a large extent: it was 0.50 at Andráshida at that time, and 0.39 at Zalaapáti, which
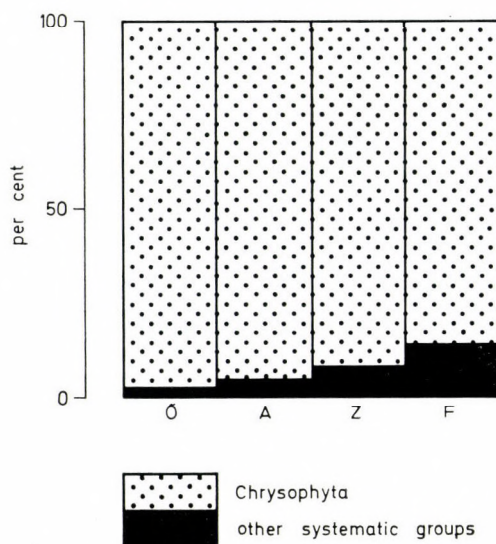
Fig. 5. **Changes in relative abundance of algal groups at different station**

total algal counts and chlorophyll-a content

1975. IV. 7–8.				1975. VII. 28–29.				1975. X. 28–29.			
Ő	A	Z	F	Ő	A	Z	F	Ő	A	Z	F
39	28	20	32	16	16	37	38	23	42	43	41
4.06	2.41	1.69	3.69	2.86	2.93	3.71	4.07	3.59	4.37	4.41	4.91
5.29	4.81	4.32	5.00	4.00	4.00	5.21	5.24	4.52	5.39	5.43	5.36
0.77	0.50	0.39	0.74	0.71	0.73	0.71	0.78	0.79	0.81	0.81	0.92
0.10	0.88	1.4	0.48	0.21	0.21	0.16	0.42	0.15	0.26	0.40	0.85
2.0	3.2	10.0	8.8	0.7	4.8	2.8	7.5	1.0	1.0	6.4	11.4
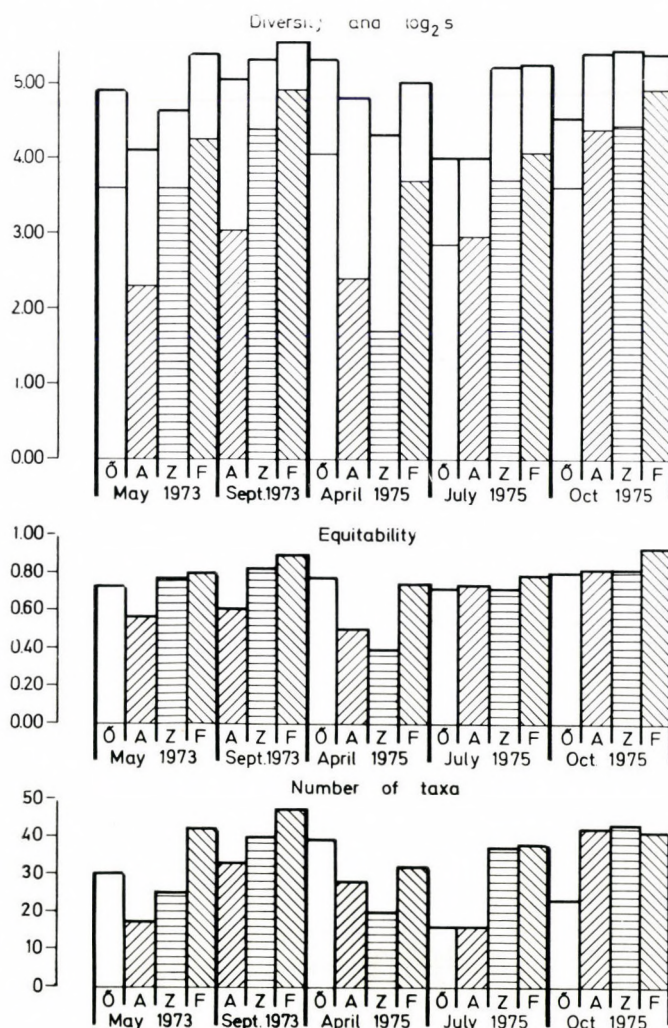
Fig. 6. **Diversity, $log_2 s$, equitability and number of taxa**

were the smallest values in the whole period of investigations. In these cases, diversity also changes in a reverse direction with the values of algal counts, characterizing the degree of eutrophication, and of chlorophyll-a content. This was not experienced in other cases; the greater values of diversity are even characteristic in general of the mouth section of the river.

The course of diversity changes is in good agreement with the taxon number characteristic of the various samples (Fig. 6).

In general the parameters of taxon number, diversity and the degree of eutrophication (total algal counts, chlorophyll-a content) all increase along the river toward the mouth. They reach their maximum values at the lower reach and indicate the direction of the changes which presumably ensue in the case of building a reservoir for the restoration of the former part played by the Kis-Balaton in keeping suspended sediment and nutrient from arriving in the river.

Summary

The phytoplankton investigations carried out in the river Zala between 1972 and 1976 gave the following results:

1. In the period of investigations 191 taxa was observed. Their breakdown according of taxonomical groups is as follows: *Cyanophyta* 11, *Euglenophyta* 8, *Xanthophyceae* 1, *Chrysophyceae* 2, *Bacillariophyceae* 125, *Cryptophyceae* 1, *Volvocales* 3, *Chlorococcales* 37, *Desmidiales* 3.

2. In all sampling sites, and considering the whole period of investigations, the taxon number of diatoms is the greatest.

3. The taxon number of the plankton algae related to the whole period of investigation increases from the direction of Őriszentpéter towards the mouth.

4. The taxon number of *Bacillariophyceae* increases after an insignificant fall at Andráshida, downriver, but at a lower rate than that of *Chlorococcales*, which also manifests from the increase of an identical direction in the *Chlorococcales* : *Bacillariophyceae* ratio of taxon number.

5. As regards the phytoplankton of the river, the dominance of *Chrysophyta* is characteristic. This phylum is represented to the greatest proportion, sometimes exclusively, by diatoms.

6. Downriver the dominance of *Chrysophyta*, primarily diatoms gradually decreases and by this the proportion of the algae belonging in other taxonomical groups increases.

7. The increase in the proportion of *Chrysophyceae*, which is represented almost exclusively by *Anthophysa vegetans*, is accompanied by a decrease in the *Bacillariophyceae* proportion.

8. Both the parameters of diversity and the degree of eutrophication (algal counts, chlorophyll-a content) increase along the river, and reach their maximum value in general in the region of the mouth.

All these changes can be brought into correlation with the considerable loading of plant nutrients, and the decrease in the flowth velocity on the river reach downstream of Zalaegerszeg; they indicate the direction of those changes which may ensue after the construction of the planned Kisbalaton reservoir.

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STUDIES ON AFRICAN CALYMPERACEAE I

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The author is working on a revision of the African species of *Syrrhopodon* and *Calymperes* genera. In the first paper of his series the descriptions of *Syrrhopodon insularum* Bizot et Onraedt and that of *S. stuhlmannii* Broth. are completed and their distribution is mapped, mainly on the basis of the rich material collected by T. Pócs in Tanzania. Special attention is paid for the leaf margin structure of *S. stuhlmannii* Broth., which differs considerably from all other species of the genus and seems to bear evolutionary significance. On this base the new *Tricostatae* section is established.

Introduction

The East African species of *Syrrhopodon* were described mostly by MITTEN (1886), BROTHERUS (1894, 1897, 1914), POTIER DE LA VARDE (1948, 1953, 1958), DIXON and THERIOT (1942), DEMARET and LEROY (1944) and finally by BIZOT (1976). Several more authors completed the picture of their distribution (LINDAU, 1895, THÉRIOT, 1931, DEMARET, 1940, DEMARET and LEROY, 1947, POTIER DE LA VARDE, 1953, 1955, 1958, BARTRAM, 1953, BIZOT and PÓCS, 1974).

The present author starts his studies with the investigation of the East African species. In the first paper of a proposed series he deals with two species, known before only from their type locality. In the case of *Syrrhopodon insularum* Bizot et Onraedt (Sect. *Cavifolii*), described on the base of a sterile specimen from the Seychelles, even its generic position was uncertain. The other species, *Syrrhopodon stuhlmannii* Broth., which was known until recent times also only by a sterile specimen, from the Uluguru Mts. Now, based on the rich material collected by T. Pócs, the author describes the sporophytes and deals with the anatomy of its leaf margin, which seems to be unique and evolutionary very important within the genus. The aim of his further studies will be a full revision of the African *Syrrhopodon* and *Calymperes* species. The limited number of species belonging to other genera was or will be revised by others (*Calymperopsis* by TIXIER, 1967, *Thyridium by* NOWAK?).

Syrrhopodon insularum Bizot et Onraedt
(Figs 1—14)

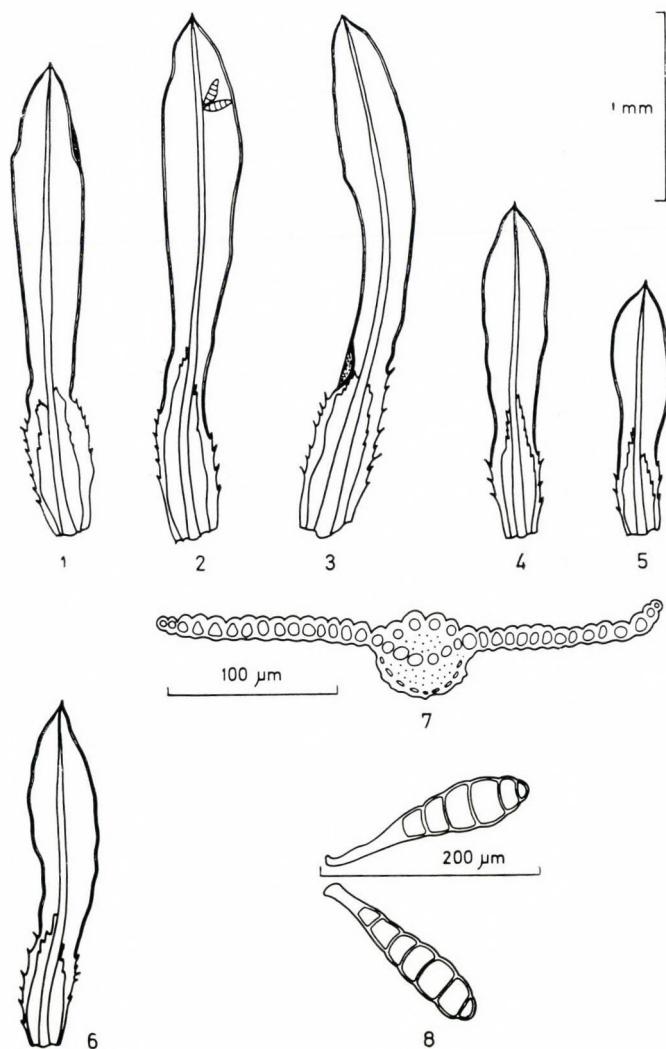
This species was recently described from the Seychelles (BIZOT, 1976) and the present Author recognized it from other collections too, as from the materials of the BROTHERUS Herbarium (Helsinki, HBR), collected in the Seychelles and among our materials (EGR) collected by PÓCS in East Africa. BROTHERUS distinguished the Seychelles specimen, as a new species on the herbarium label (*S. divergens* nom. herb.), but never described it.

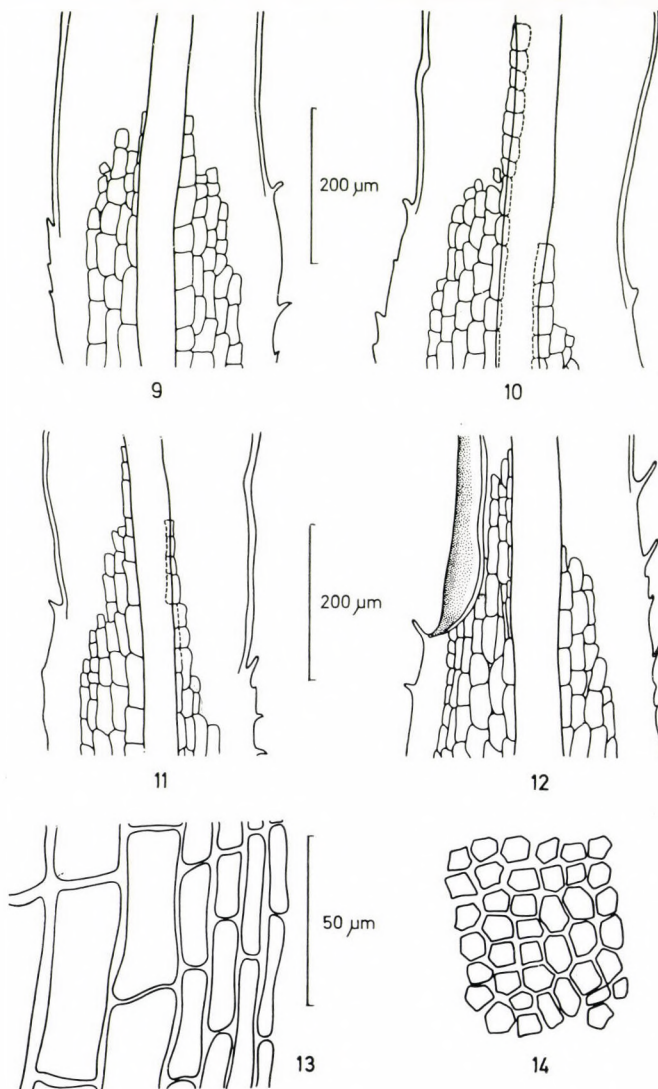
Syrrhopodon insularum is a tipical member of the *Cavifolii* Section, and the only one, which occur in East Africa. Its distribution in the Mascarenes, Madagascar and in the Uluguru Mountains underlines again the old links between these mountains and the East African Islands (cf. PÓCS, 1975). Its known total distribution is (see Fig. 28):

Reunion — Réserve forestière de la Mare Longue près de St. Philippe, sur les arbres d'une foret primaire dégradée humide, 200 m, 18. 12. 1969, ONRAEDT 69 R 963 (type).
Seychelles — Mahé, Cassada Mts., leg. J. S. GARDINER, 1908 (HBR — sub nomine *Syrrhopodon divergens* Broth. nom. herb.).
— Ile Mahé, foret du Morne Blanc sur bois pourri en sousbois, 23. 1. 74, ONRAEDT 4 S 109.
Madagascar — Ad ligua putrida. Cerele M^{e} on Bara, secteur d'Ivondro, poste de Soaramo. leg. CROLL, 1900, ex Herb. G. Paris (HBR — separated from the *Syrrhopodon sparsus* R. et C. material).
Tanzania — Uluguru Mts., Submontane rain forest on the SE slope of Mt. Tumbako, 1050—1390 m, coll.: T. PÓCS and M. LUNGWECHA, 6875/L, 6875/M, EGR, BP, DSM, EA.

On the base of the observed specimens I tried to complete the descriptions of this interesting species: Coritcolous, forming dull green, inside brownish mats, which fall easily to parts. Stem 10—20 mm long, densely foliated, near the apex branching, and nearly in whole length covered by red rhizoids. The upper 5—10, living leaves are green, the lower ones brownish and bruised. The upper leaves, when dry, are bent or curled, in wet condition straight patent, 2.5—3 mm long, 0.4—0.5 mm broad, their margins slightly incurved. The lower leaves are shorter and broader, when entire. The sheathing part is scarcely broader than the lower part of free lamina, narrow obovate, occupies 1/4—1/3 of the whole leaf length. The margin of the sheathing part is armed by short (12—33 μm), unequal, upwards directed, acute teeth. The blade is elongate-lanceolate or ligulate-lanceolate, with a short, mucronate apex.

The hyaline cells border the blade in two rows up to the apex or near so. The hyaline border almost disappears downwards, near the first ciliae forming a 1 cell broad margin, than at the base of the sheathing part again into a 4—5 cells broad border. The hyaline border in its whole length is 1 cell layer thick. The midrib is 50 μm broad at its base, upwards gradually tapers off, backside smooth or with scattered, blunt papillae. The ventral face of the blade midrib is rough by the mamillose bulges of the covering cells, which are slightly

larger than the lamina cells and are arranged in lines. These emergent cells are not present on the sheath midrib. The cancellinae (endohyalocysts) are arranged in 4—5 rows on each side, greater along the midrib (45—50 × 20—25 μm) narrower and shorter near the border (35—40 × 10—12 μm). The cancellinae accompanying the midrib are excurrent in the blade, elongate rectangular. The chlorocysts of the lamina are 7—10 μm in diameter, quadrate, rectangular or irregular hexagonal. Their dorsal face smooth or minutely papillose, ventral face mamillate. Sporophyte unknown. Vegetative reproduction

Figs 1—8. Syrrhopodon insularum Bizot et Onraedt 1—3: Leaves from the upper part of the stem. 4—6: Lower leaves. 7: Transversal section from the middle of an upper leaf. 8: Propagules

by clubshaped propagulae, which develop on the upper third of the midrib, forming small groups or clusters. The propagulae are 160—180 μm long, divided into 6—10 septae, similar to that of the other members of the Section. At the same time, the arrangement of propagulae makes clear the generic position of this species, excluding the possibility of a *Calymperopsis*. On the other hand, it was observed, that the spherically protruding cells on the ventral

Figs 9—14. Syrrhopodon insularum Bizot et Onraedt. 9—12: Cancellinae (endohyalocysts) at the upper part of the sheath. 13: Cancellinae from the leaf base. 14: Chlorocysts from the leaf blade. All drawn from Pócs—Lungwecha No. 6875/L, by S. Orbán

face of midrib become easily detached, probably serving also the purpose of vegetative propagation.

Observations: *Syrrhopodon insularum* differs in several aspects from the West African ciliferous species, likewise from the Asian ones. The most conspicuous feature, well observed by its author, M. Bizot too, are the sphaeric, protruding, detachable cells arranged in lines on the ventral surface of the midrib. The west African and Asian species of the section (*S. armatus*, *S. afrociliatus*, *S. paucifimbriatus*, *S. larminatii* and others) bear elongated quadrangular cells at the same site, which are not sphaerically protruding, but usually possess a large acute papilla, which in many cases is prolonged in a spine.

The broad lamina and the hyaline border reaching the apex show affinity to the Asian species, on the other hand the cancellinae far adcurrent to the costa is a feature common with the African species. This mean difference between the species of African and Asian *Cavifolii* was shown also by pictures by Pócs and Tixier (1967: 127, 129), who established, that all African *Cavifolii* have adcurrent cancellinae, while some of the Asian members of this section have cancellinae, which end abruptly in a rounded group near the blade.

Further differences are that the adcurrent cancellinae near the midrib end in a group of elongate quadrangular cells, which are only slightly shorter, than the other endohyalocysts. At the same time the cancellinae of other African *Cavifolii* end in pearllike rows of rounded cells, which gradually diminishing in size (cf. figures of Pócs and Tixier, 1967: 129). The ciliae of the sheath by *S. insularum* are much shorter and more unequal, then by the related species, and are very rigid, and directed towards the apex. The chlorocysts are similar in size to the other species of the section, but differ from the African *Cavifolii* not bearing papillae at all, only slightly mamillose on their ventral face. Due to the almost smooth cells the upper part of lamina is translucent. The only from this point of view, comparable Asian *Cavifolii* taxon is *Syrrhopodon larminatii* var. *epapillosa* Pócs et Tixier, which also differs by the arrangement of cancellinae and by the spinose midrib and leaf shoulder.

The only known locality of *Syrrhopodon insularum* Bizot in East Africa lies in the north eastern part of Uluguru Mountains. The plant is corticolous, in a submontane rain forest developed by continons high rainfall round 3000 mm/year without dry season. The dominant trees are *Ocotea usambarensis*, *Myrianthus holstii*, *Allanblackia stuhlmannii* and *Cylicomorpha parviflora*. Vascular and micro-epiphytes are abundant (Pócs, 1976: 486). All West African members of the *Cavifolii* section are tropical rain forest dweller or are living by similar climatic conditions. In East Africa lowland rain forest habitats are quite seldom, restricted to the rainy, eastern slopes of the Usambara, Nguru and Uluguru Mountains, probably this is the reason, why representatives of the *Cavifolii* section are so rare here (personal communication by T. Pócs).

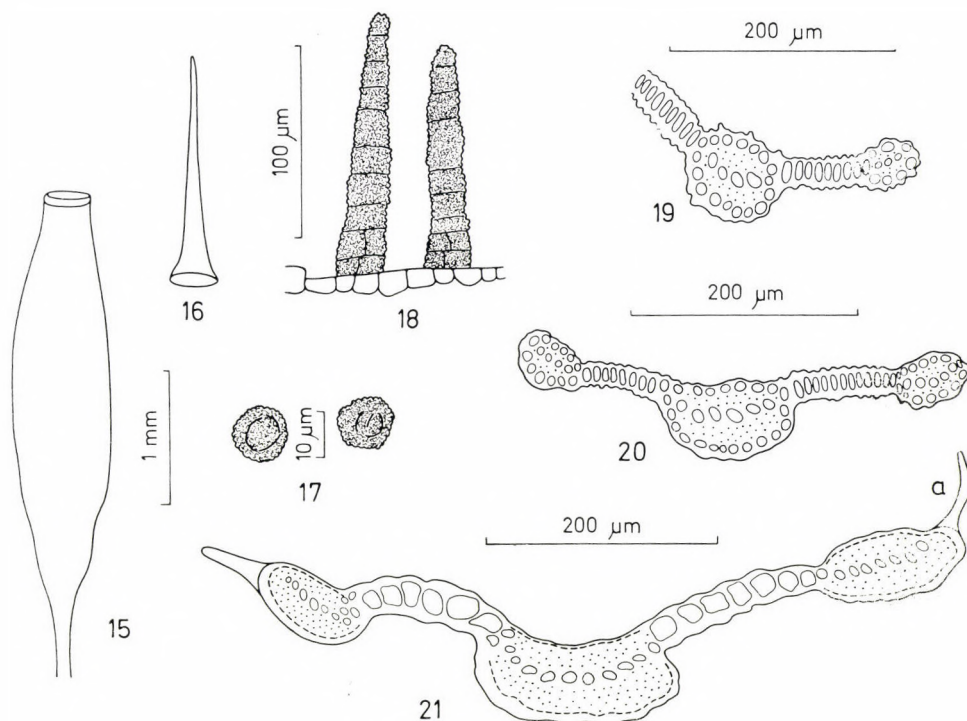
Syrrhopodon stuhlmannii Broth. (Figs 15—26)

This moss species was described by BROTHERUS in 1897 based on the material collected by STUHLMANN under No. 8809 from the Uluguru Mts. in Tanganyika, East Africa. The moss was not collected for more than 70 years, until T. PÓCS carried out a detailed vegetation mapping and systematic collecting in the mountains, and collected it from so many localities, that the description could be completed and a comprehensive picture of the distribution of this interesting endemic species could be drawn. (Three of these localities were published in PÓCS—BIZOT, 1974: 421).

As compared to the original diagnosis of the species (BROTHERUS, 1897: 240) the author, studying the rich material, has observed many interesting morphological features, which were not included, especially concerning the sporophyte and the anatomy of leaf margin. Therefore a new, more complete description is given:

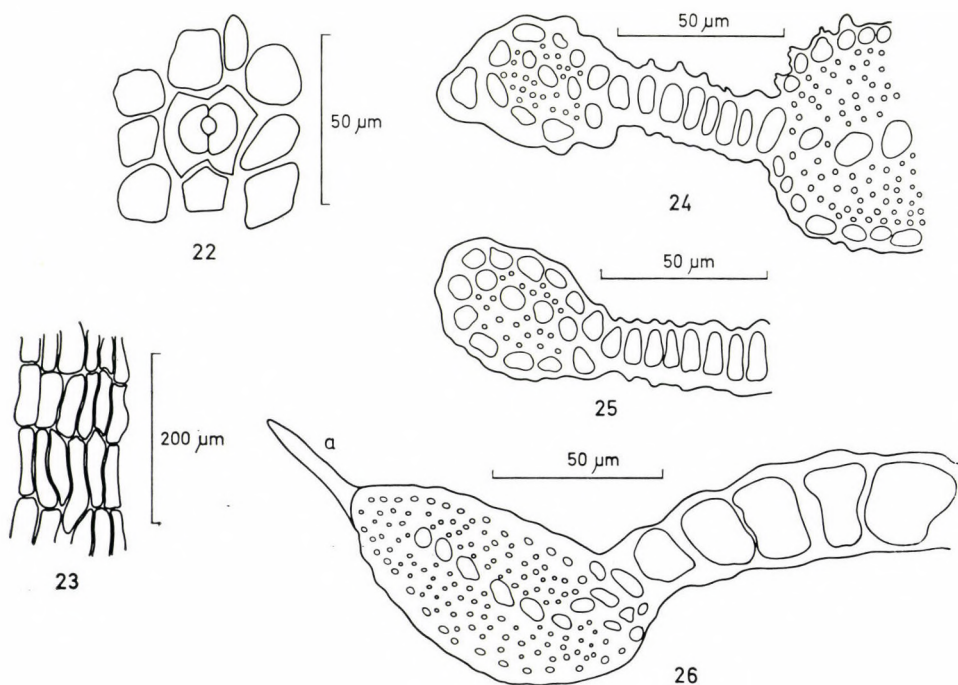
Dioicus. Forms large, dense *Dicranum* like cushions and mats up to 20 cm thickness and covering sometimes several square metres of surface. The cushins outside are vivid green in fresh, dark green when dry, inside rusty brown, interwoven by rhizoids. The stem is 3—20 cm long, erect, densely covered by *Dicranum* like, falcate leaves whith shiny, white sheaths, and by reddish brown rhizoids, simple or dichotomously branched below apex. Its lower part gradully dies off and merge in a peat like stuff formed by the lifeless shoot parts. The leaves are 10—12 mm long, 0,3 mm broad in their upper and 0.8—1 mm broad at their lower part, falcate, rigid; patent when dry, unilaterally bent in wet conditions, their blade narrow linear. The leaf margin is strongly thickened, in cross section rounded, 35—40 μm in diameter along the blade and 130—150 μm broad on the sheath. In its transversal section several layers of stereid cells are seen covered by a one layered epidermis and with conducting cells of more spacious lumen in the median line. (See 19—21, 24—26 Figures.) The shoulder of the sheath is densely ciliate, the margin of the blade is dentate with double teeth in its upper half. The midrib is very vigorous, 160 μm broad at the base, upwards tapering off and about 35 μm where ends in the apex. The back of midrib is covered by blunt papillae. The cancellinae form a triangle with its apex penetrating in the blade. The endohyalocysts are short quadrangular, 36×13 μm large, along the midrib somewhat longer. The chlorocysts are rounded quadrangular, small, 8 μm in diameter, ornated by blunt verrucose papillae (see Figs 19, 20, 24). The sporophytes develop quite often. The capsule is oblong-obovate, 3 mm long, erect (see Fig. 19), shiny rusty brown, its short, tapering neck with several scattered stomata (see Fig. 22) of the phaneropor type. The seta is 10—15 mm long, smooth, shiny, brown, twisted in dry condition. The peristomium is simple, with 16 linear teeth, each 8—10 septate (see Fig. 18). Their upper part

is pale yellow, lower brownish, with strongly warty surface. The exothecium cells are elongate rectangular or sexangular (Fig. 23). The lid is elongated conic (Fig. 26). The calyptra is straw coloured, cucullate, smooth, covers the capsule in its whole length. Sporae globular, 12 μm in diameter, minutely warty (see Fig. 17).

The author would like to lay particular stress on the leaf anatomy, especially on the structure of the thickened border, seen in the transversal section which shows a unique structure within the genus according to our present knowledge. DEMARET and LEROY (1947: 209—211) divided the subgenus *Orthotheca* into two sections according to their thickened margins: the first one with triangular or trapezoid transversal section without stereids, and the second with pluriangular shape in section with incrassate walled stereid cells. Studying the transversal leaf section of *S. stuhlmannii*, it became clear, that in its thickened, in cross section rounded border, beside the outher cell layer and beside the stereids, there are also central conducting elements (see Fig. 19—21, 24—26). In this manner the structure of the border agrees with that

Figs 15—21. Syrrhopodon stuhlmannii Broth. 15: Capsule. 16: Lid. 17: Spores. 18: Peristomium teeth. 19: Transversal section from the upper third of an average leaf. 20: Ditto, from the middle. 21: Ditto, from the leaf sheath centre. — a: Cilia. Drawn from Pócs—Mwanjabe—Sharma No. 6579/E, by S. ORBÁN

of the midrib. This feature seems to be an important evolutionary step within the subgenus *Orthotheca*. Although the leaf border structure is the most differentiated by our species within the subgenus, many facts suggest, that this is a primitive character. Such evidences, as the mostly terricolous manner, very large size (up to 20 cm height), the stomata on the capsule neck seem to prove its archaic character beside the endemic occurrence in cristalline massifs of precambrian age. It should be possible, that all small sized, epiphytic species developed from this archaic types of *Syrrhopodon*. Similar, in cross section round bordered species, as *S. polytrichoides* from New Caledonia and *S. croceus* from Oceania show similar size and habit although here lack the conducting elements from the border.

On the base of the peculiar leaf border anatomy a new section is proposed for *Syrrhopodon stuhlmannii*, within the subgenus *Orthotheca:* Sectio nova *Tricostatae*. Margo foliis in sections transversalia rotundata, compositione costae similis.

Distribution: Endemic in East Africa, Tanzania, in the old cristallins massivs of Uluguru and Nguru Mountains. In the Ulugurus is distributed

Figs 22—36. Syrrhopodon stuhlmannii Broth. 22: Stoma from the capsule neck. 23: Exothecium cells. 24: Transversal section from the upper part of an average leaf. 25: Ditto, from the middle of the blade. 26: Ditto, from the sheath centre. — a: cilia. Drawn by S. Orbán, from Pócs—Mwanjabe—Sharma No. 6579/E

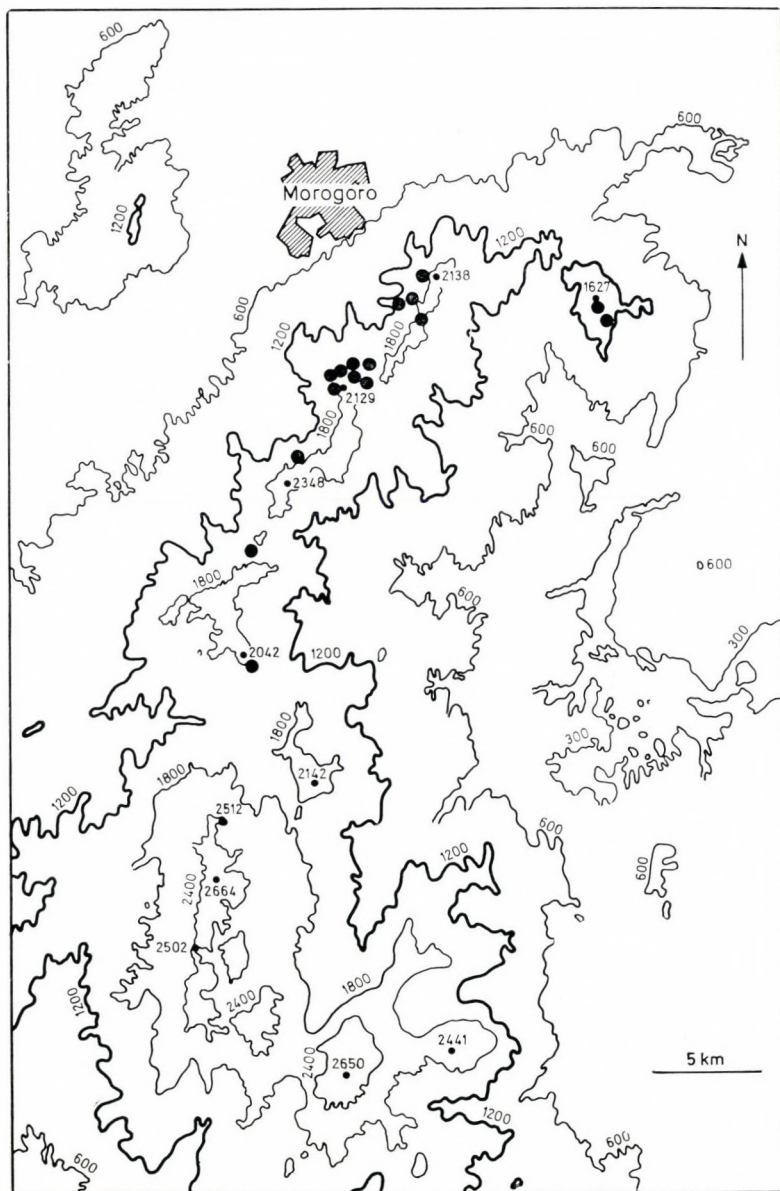



Fig. 27. Distribution of *Syrrhopodon stuhlmannii* in the Uluguru Mts. (Drawn by T. Pócs)

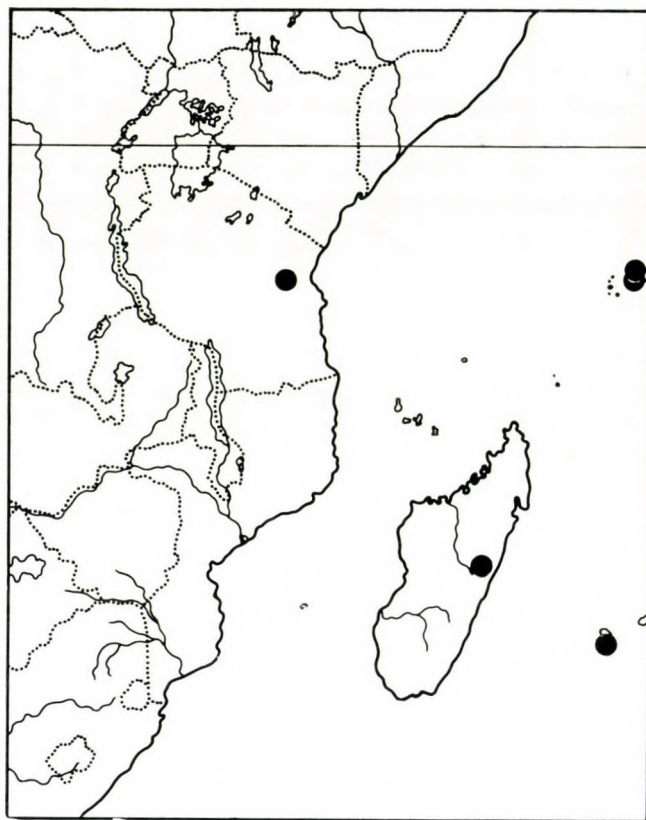



Fig. 28. Distribution of *Syrrhopodon insularum* in the East Africa and the East African Islands

only in the northern, more humid part of the mountains, where many localities are known, while only one locality was detected from the Ngurus, where it might be also more widespread (see Fig. 27).

The collecting numbers are that of T. Pócs. He was often accompanied by colleagues, assistants and friends. All specimens were collected between August 1969 and March 1973. (The exact type locality is not known, because the type specimen bear only the data: Uluguru Mts., 1600 m altitude.)

Uluguru Mts. Mt. Lupanga above Morogoro town, W ridge 1850—1900 m — 6549/C; SW ridge above Mbete village, 1700—1900 m — 6285/CF, CG; ridge between Lupanga and Kinazi peaks, 1800—1900 m — 6836/Q; SE and S slopes of Mt. Tumbako, NE of Kinole village, 1340—1530 m — 6876/O, 6877/U; SE, E, NE and N slopes and the top of Mt. Bondwa, S of Morogoro town, 1600—2120 m — 6051/BJ, 6052/C, 6232/L, 6260/G, 6261/R, 6398/D, 6404/AA, 6526/AA, 6535/H, 6574/C, 6578/G, JA, 6579/C, E, 6599/E, K; valley on the NNE slope of Magari peak, 1500—1800 m — 6296/W; Mlulu valley NE above Tangeni village, 1450—1550 m — 6558/K; Mt. Kifuru top, N of Bunduki, 1980—2010 m — 6915/S.

Nguru Mts. Dunema ridge S of Kwamanga village, above Mhonda Mission — 1400—1500 m — 6398/D.

Ecology: It grows only in such montane rain forests and in elfin forests, where the main annual rainfall is higher than 3000 mm and no dry season occurs, between altitudes of 1340 and 2120 metres. Its occurrence in large masses is characteristic in the high altitude mossy forests and in the subalpine elfin forests above 1800 m altitude, where it covers by a thick carpet and by large cushions the ground and is able to develop a fur on all parts of the trees. It was observed 10 times as terricolous, in 10 cases as corticolous, four cases on rotting wood and in two cases on smaller branches. Sporophytes were seen 8 times out of 26, both on soil and on bark. The plant plays an important role in the water interception and humus formation of the mossy rain forests.

ACKNOWLEDGEMENT

The author expresses his gratitudes towards T. Pócs for the admission of his rich collection of Calymperaceae for studies, and for helping in many ways, towards Miss I. Järvinen for the loan of the type material of *S. stuhlmannii* from the Helsinki (H) Herbarium.

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CHANGES IN THE PHYTOMASS AND PRODUCTION OF THE HERBACEOUS LAYER IN THE QUERCETUM PETRAEAE-CERRIS FOREST AFTER SELECTING BY FORESTERS*

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The paper discusses the production biological examinations of the part of the *Quercetum petraeae-cerris* forest stand of the "Sikfőkút Project" research area (JAKUCS, 1973) in which the foresters carried out selecting in September 1973, with an aim of later deforestation. As a result of opening the canopy to a considerable extent, and of the removal of the shrub layer, the environmental factors changed strongly, especially the quantity of radiation reaching the herbaceous layer.

The number of individuals in the herbaceous layer and the changes in its cover, as well as the changes in the quantity of phytomass and production — by the example of the two dominant plant species — are analysed by means of a comparison with the corresponding data of the natural forest.

It is stated that the number of individuals and the cover for 1 ha increased 6.0—6.5 times to that occurring in the natural forest, and again the quantity of phytomass and production increased to its 10—30 folds.

Introduction

In September 1973, the foresters carried out a selection aiming at deforestation in a 10 ha forest portion belonging and completely corresponding to the intensively investigated forest stand within the framework of the MAB program of Hungary. In the pre-cut area, only about a quarter of the wood stand of the forest was left to ensure the natural regeneration of the forest by means of its a corn crop. While in the natural forest there are 816 oak individuals growing in 1 ha, the number of trees in this 1 ha area is 226 at present. The average distance of the trees from one another has become about 10 m as against about 3 m average trunk distance in the natural forest. The estimated coverage of the foliage dropped below 20%, while formerly it had been 79.9% (MAJER, 1974, JAKUCS—HORVÁTH—KÁRÁSZ, 1975). In the shrub layer of the selected forest there remained only some sprout individuals, which in itself means a considerable structural difference in comparison with the rich shrub layer of the natural forest (KÁRÁSZ, 1976).

The sudden and drastic alteration of the structure of the natural forest ecosystem completely upset the relatively permanently stable functioning

* "Sikfőkút Project" No. 26.

of the ecosystem. In the herbaceous layer of the closed natural forest, phytomass and production investigations had been carried out continually since 1973. In the second year following the selection, the investigations were extended to the herbaceous layer of the neighbouring pre-cut fores too.

It was by this means that we wanted to obtain data on the reaction of the undergrowth of the remaining forest, which had been deprived of a considerable part of its phytomass and primary production, to the changed environmental effects accompanying the changes in structure. Among these effects the cessation of the radiation screening effect of the closed forest can be judged as the most important. Namely, the quantity of the short and long-wave radiation can penetrate almost without obstacle into the stand which has been thinned and deprived even of its shrub layer, this causes completely different ecological conditions for the herbaceous species which had assimilated to the shaded, slightly mesophyl ecological conditions of the forest.

We are also certain that the causes of the changes to be described below should be found, besides the microclimatic changes indicated above, in the fact that owing to the thinning of the trees and the disappearing of shrubs, the soil an organic matter of the forest ecosystem, which had been in equilibrium for many years, has become virtually immediately usable for the herbaceous layer.

Our investigations are related to the second year following the intervention, that is, to 1975. Since the intervention, which had been begun, has been stopped for a long time — for the very reason of investigating the changed conditions — we intend to repeat our present survey at a later time too.

Here we mention that 1975 in its climatic nature was relatively warm (yearly average 10.7 °C) and rich in moisture (yearly amount 714 mm). Warming up at spring-time started very early (February: 0.7 °C, March: 7.9 °C), and again the permanent warm weather ceased only by the end of September. Precipitation appeared definitely in the midsummer maxima (showers, storms) (June: 145.8 mm, July: 114.3 mm, August: 97.5 mm) and we observed only a very small (a quarter of a fifth) maximum in March and in October. The early strong warming up, the relatively small quantity of precipitation in spring, and the warm period without precipitation in September, as well as the warm moist weather in summer, in comparison with that of the two previous years of a different climatic nature, became expressed also quantitatively in the changes of phytomass and production.

Sampling

The description of the methods of harvest and the monolithic method, or that of the individual plant sampling, had been given earlier (Jakucs—Papp, 1974). The method of recording the species count the number of individuals and the coverage data necessary for the recalculations per ha was also similar to that applied in the herbaceous layer of the natural

ecosystem: we counted in 10 randomly marked, 4×4 m areas. We considered the 10 times repetition of the counts enough, because the herbaceous plants in the area closed immediately and appeared no longer in mosaics but approximately in a homogeneous arrangemenet.

The detailed seasonal phytomass examinations were made for two species, *Dactylis polygama* and *Poa nemoralis*, since in our estimation these two species can give 70—80% of the phytomass or production of the area (in the natural forest they give 48—55%, according to our measurements). In the case of *Dactylis polygama*, we applied the individual plant method, while the samples of *Poa nemoralis* were collected by harvesting or monolithic sampling. In both of the areas, the samples were taken at identical points of time.

Results and discussion

Changes in the specimen and the cover conditions

In a comparison between the two areas (natural forest and selected forest), it can be immediately stated that under the effect of the changed environmental factors the herbaceous layer in the thinned forest has completely overgrown the soil surface. The mosaic herb layer, corresponding to the light conditions which is characteristic of the natural closed forest, has completely transformed during the two vegetational periods. The short period that has elapsed is not yet enough to check the changes in species composition, therefore we present first the changes that ensued in the number of individuals in the various species and in their cover (Table 1).

It can be seen from the Table that against 1 539 187 individuals per ha in the natural forest, 9 774 600 plant individuals in 1 ha could be counted

Table 1

Number of individuals and cover of the herbaceous layer per 1 ha of the closed (A) and selected (B) forest

Species	Specimens		Cover (per cent)	
	A	B	A	B
Carex michelii	89 782	148 438	5.7	12.9
Carex montana	68 866	519 750	3.5	29.5
Chrysanthemum corymbosum	76	3 312	0.1	3.4
Dactylis polygama	39 310	309 938	4.1	29.0
Festuca heterophylla	25 417	149 563	1.0	9.0
Fragaria vesca	2 293	16 937	0.7	5.0
Galium schultesii	13 347	92 937	4.0	19.2
Lathyrus niger	912	3 437	0.7	2.9
Lathyrus vernus	199	8 000	0.3	5.1
Melica uniflora	302 806	390 000	3.9	6.5
Poa nemoralis	975 832	7 971 500	6.6	50.8
Other	20 347	160 788	1.4	29.8
Σ	1 539 187	9 774 600	32.0	203.1

in the pre-cut forest. The latter value is 6.35 fold of the former. The cover of the herbaceous layer of the selected forest changed to a similar extent. It became 6.39 times greater (203.1%) than the value measured in the natural forest (31.8%).

In a comparison between the number of individuals and cover data of the various species in the two areas, the following inferences may be mentioned: Among the recorded 11 species, the greatest difference in the number of individuals occurred in *Chrysanthemum corymbosum* in the two areas. In the selected forest the individuals of the species mentioned was about 43 times greater per ha, and again its value of cover 57 times greater. Similarly, the number of individuals of *Lathyrus vernus* was about 40 times greater, whereas its cover value increased only to 20 fold. This may imply that for the increase in *Lathyrus vernus* the changed surroundings were favourable — at least in the first years — while at the same time it developed a much smaller assimilatory surface than in the closed forest. It should also be mentioned that hardly any change occurred in the number of individuals and cover values of *Melica uniflora* (the number of individuals per ha is 1.29, its cover 1.65 times greater). Similarly, hardly any changes could be found in the *Carex michelii* values. Both species responded to the changes rather by developing a larger assimilatory surface.

Finally, we also mention that in the category of "others" the specimen number increased to a much smaller extent than the coverage value. This supports our observation, namely that in the pre-cut area primarily the specimen numbers of species increased whose leaf area is of greater size — mainly that of dicotyledonous species (for example, *Silene vulgaris*, *Melampyrum nemorosum*, *Symphytum tuberosum*, *Campanula trachelium*, *Trifolium medium*, *Cynanchum vincetoxicum*, etc.).

The evaluation of phytomass and production as well as certain related indices, on the basis of the two test species

Dactylis polygama

The phytomass data per 1 ha in a breakdown of three fractions in both the closed and the selected forest are summarized in Table 2 and illustrated in Fig. 1.

In the case of the above-ground living fraction, a course of changes with two maxima can be experienced in both areas. The first maximum appeared in the closed forest in the middle of July, the second two months later, in the middle of September. In the herbaceous layer of the thinned forest, this species gives a smaller maximum, as early as the end of May, while the second maximum which represents a greater value of biomass, similarly to the closed forest,

appeared with a two-month delay, by the end of July. The value of the first maximum is 16 times greater, that of the second maximum 27 times greater, in the thinned forest.

The change of course of the above-ground dead fraction was also similar in the two areas. The greatest phytomass values were measured at the sampling after the summer minimum appearing in both areas (in the closed forest in
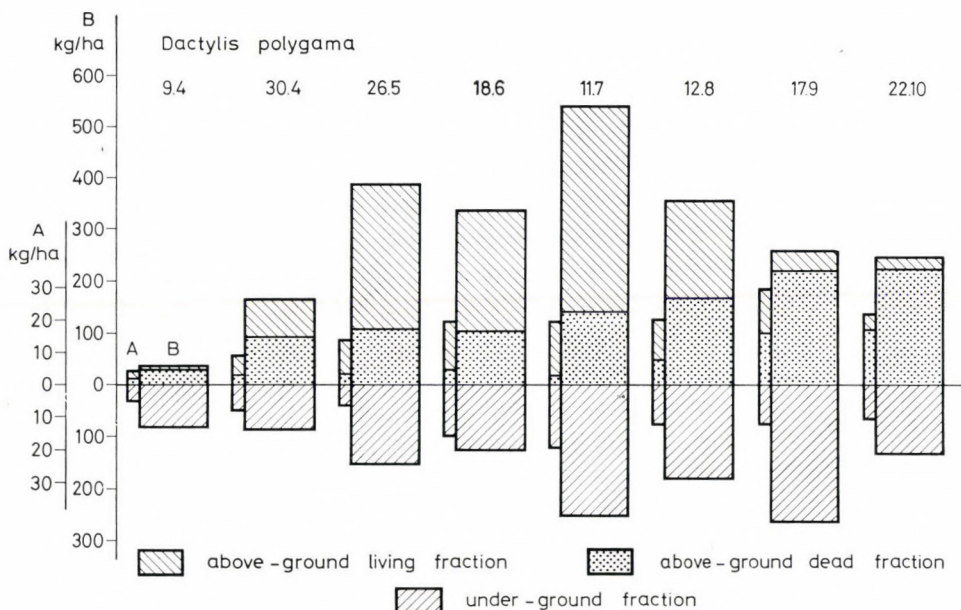
Fig. 1. Monthly changes in the phytomass fractions of *Dactylis polygama* in closed (A) and selected (B) forests — kg/ha

the middle of July, in the thinned forest in the middle of June). The phytomass of the dead fraction was of a value about 13 times greater in the thinned forest.

The root phytomass showed a greater value in the middle and at the end of the vegetative period. In the middle of July its quantity was of a considerable value in both areas, that is 20.10 and 254.49 kg/ha, respectively. The first value (measured in the closed forest) is 13 times smaller than the second.

In the case of the above-ground fraction, the value of the yearly production (the difference between the maximum and minimum phytomass) was calculated that the growth of the dead fraction, measured up to the time of the maximum of the living fraction, was also considered. The concurrently decomposed quantity could not be considered.

While the yearly above-ground production of *Dactylis polygama* plants growing in the closed forest was 19.39 kg/ha, and again its underground pro-

duction was 14.80 kg/ha, in the area which received a greater quantity of radiation we measured 510.70 kg/ha/year for the above-ground parts, and 178.7 kg/ha/year for the underground parts. In a comparison the above-ground fraction value is 26 times, that of the underground fraction 12 times greater than the corresponding values of the natural forest.

Concerning the above-ground living fraction, we measured the greatest weight increase per day in May and June (+0.021 g/m²/day) in the closed forest, and again in May (+0.790 g/m²/day) in the thinned forest. The greatest weight decrease indicating the process of decay was measured between the two last samplings in the closed forest (—0.027 g/m²/day), while in the thinned forest it occurred much earlier, in July and August (—0.662 g/m²/day) (Table 3). One of the reasons of this is that the high temperature during mid-

Table 2

Monthly dry weight data of the phytomass fractions in Dactylis polygama in closed (A) and selected (B) forests — kg/ha

A

	Above-ground fractions		Underground fractions	Σ
	living	dead		
9.4	2.87	2.08	5.66	10.61
30.4	6.84	3.26	8.96	19.06
26.5	11.52	3.58	7.15	22.25
18.6	16.24	5.15	16.59	37.98
11.7	17.74	3.03	20.10	40.87
12.8	13.88	8.18	12.97	35.03
17.9	14.94	16.75	12.85	44.54
22.10	5.46	18.04	11.24	34.74

B

	Above-ground fractions		Underground fraction	Σ
	living	dead		
9.4	2.29	36.57	83.96	122.82
30.4	78.72	93.29	88.19	260.20
26.5	284.21	108.79	156.53	549.53
18.6	237.41	105.69	126.92	470.02
11.7	403.23	143.19	254.49	800.91
12.8	191.54	166.93	182.03	540.50
17.9	39.98	224.09	262.63	526.70
22.10	23.87	226.88	134.73	385.48

Table 3

Productivity values of the phytomass fractions in Dactylis polygama (g/m²day) in closed (A) and selected (B) forests

A

	Above-ground fractions		Underground fraction
	living	dead	
9.4—30.4 21	+0.019	+0.006	+0.016
30.4—26.5 26	+0.018	+0.001	—0.007
26.5—18.6 23	+0.021	+0.007	+0.041
18.6—11.7 23	+0.006	—0.009	+0.015
11.7—12.8 32	—0.012	+0.016	—0.022
12.8—17.9 36	+0.003	+0.024	—0.001
17.9—22.10 35	—0.027	+0.004	—0.005

B

	Above-ground fractions		Underground fraction
	living	dead	
9.4—30.4 21	+0.364	+0.270	+0.020
30.4—26.5 26	+0.790	+0.060	+0.263
26.5—18.6 23	—0.204	—0.013	—0.129
18.6—11.7 23	+0.721	+0.163	+0.555
11.7—12.8 32	—0.662	+0.074	—0.226
12.8—17.9 36	—0.421	+0.159	+0.224
17.9—22.10 35	—0.046	+0.008	—0.365

summer (July: 20.4 °C, August: 19.5 °C) and the dryness of midsummer, which can accelerate the process of decay, is to a certain extent compensated in the closed forest by the shrub and tree foliage.

The values of dead fraction productivity in the closed forest varied between —0.009 and +0.024 g/m²/day, and again in the thinned forest between —0.013 and +0.270 g/m²/day.

The growth of the underground fraction in the closed forest was the most significant between May and June (+0.041 g/m²/day), and again in the thinned forest between June and July (+0.555 g/m²/day).

The exchange turnover rate (ODUM, 1960) was almost identical in the two areas. The 92% and 99% aboveground living fraction values, respectively suggest that *Dactylis polygama* carries over only a minimum quantity of green matter for the subsequent vegetation period. The dead fraction on the other hand remains standing for a longer period (turnover rate: 88% and 84%) respectively. The corresponding turnover time is 1.2 years on the average.

The turnover rate of the underground parts proved to be the slowest (74% and 68%), respectively. The turnover times corresponding to these values were 1.4 and 1.5 years, respectively.

The values of the Root Importance Index calculated for the various samplings (STRUIK, 1965, STRUIK—BRAY, 1970) are to be found in Table 4. In both areas, the importance of the root in the total phytomass was the greatest in the period of the first sampling (53.55% and 68.36%, respectively). In the further samplings, the values remained below 50%, and it was only by the end of the vegetation period that they resumed an increasing trend in both areas.

Table 4

Changes of the root importance indices of Dactylis polygama in closed (A) and selected (B) forests

Sampl-ing	9.4	30.4	26.5	18.6	11.7	12.8	17.9	22.10
A (%)	53.35	47.00	32.13	43.68	49.18	37.02	28.85	32.35
B (%)	68.36	33.89	28.48	27.00	31.77	33.68	49.86	34.95

Poa nemoralis

The data of the phytomass fractions per 1 ha are given in Table 5 and illustrated in Fig. 2. In a comparison with the weight data per 1 ha of *Dactylis polygama* discussed above it is immediately clear that the weight data of *Poa nemoralis* are greater by an order of magnitude per unit area.

The above-ground living phytomass fraction in the closed forest, starting from the low values at early springtime and continuing with rapid changes shows a maximum as early as mid-July. Although at the samplings following this, the values are lower, still they represent considerable phytomass throughout. This maximum in the thinned forest is shown only in mid-August. Its values is on the other hand about 19 times higher than that measured in the natural forest.
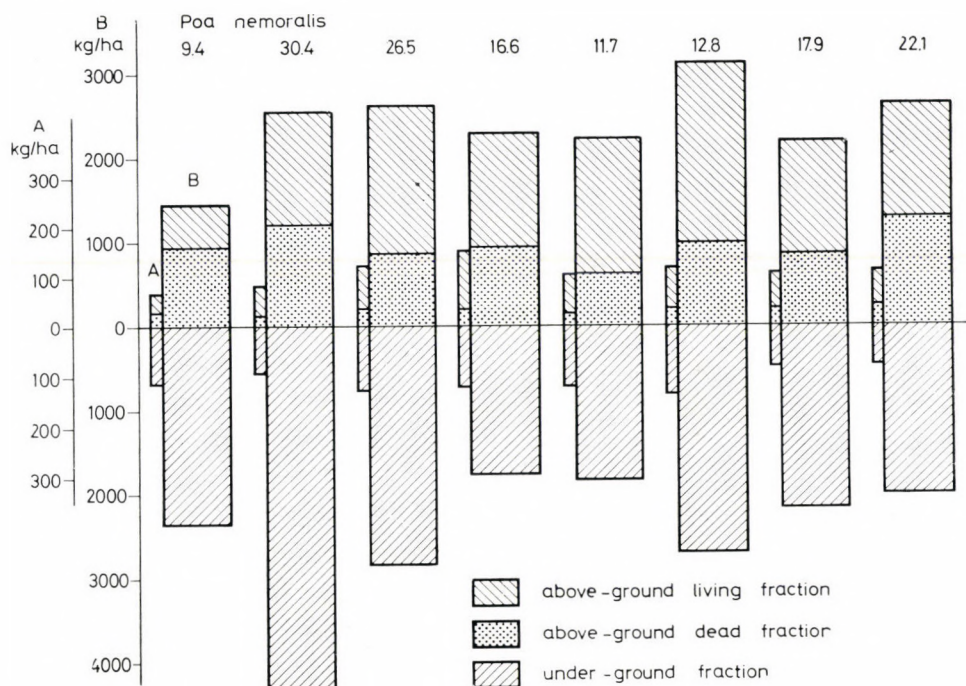
Fig. 2. Monthly changes in the phytomass fractions of *Poa nemoralis* in closed (A) and selected (B) forests — kg/ha

It was characteristic of the course of changes in the phytomass of the above-ground dead fraction that even three smaller maxima were measured during the vegetation period until the more intense increase in autumn started. In both areas, the main maxima were measured at the time of the last sampling and this in the thinned forest was 34 times greater than in the closed forest.

The quantities of the under-ground phytomass in both areas were the greatest in spring and in the late summer months. The maximum root phytomass of the thinned forest was 31 times greater than that measured in the closed forest.

The yearly above-ground production of Poa nemoralis in the closed forest was 119.53 kg/ha and in the selected forest 4055.11 kg/ha, that is,

Table 5

Monthly dry weight data of the phytomass fractions of Poa nemoralis in closed (A) and selected (B) forests (kg/ha)

A

	Above-ground fractions		Underground fraction	Σ
	living	dead		
9.4	37.74	26.28	115.68	179.70
30.4	63.27	19.87	97.45	180.59
26.5	89.09	32.85	131.07	253.01
18.6	115.57	31.93	124.73	272.23
11.7	78.84	23.65	124.51	227.00
12.8	81.50	31.90	136.11	249.51
17.9	72.34	30.62	85.54	188.50
22.10	68.39	37.65	81.47	187.51

B

	Above-ground fractions		Underground fraction	Σ
	living	dead		
9.4	530.86	927.86	2361.63	3820.35
30.4	1359.62	1186.18	4289.60	6835.40
26.5	1799.84	870.20	2847.29	5517.33
18.6	1392.94	942.85	1787.42	4123.21
11.7	1620.52	620.27	1830.10	4070.89
12.8	2156.21	978.66	2717.14	5852.01
17.9	1349.76	834.64	2164.54	4348.94
22.10	1367.41	1267.97	2014.65	4650.03

34 times greater. The underground fraction production, similarly as in *Dactylis polygama*, is smaller than the above-ground production in both areas. In the closed forest it is 60.58 kg/ha/year, in the thinned forest 1927.97 kg/ha/year (the latter value is 32 times higher).

The productivity value expressing the daily growth (Table 6) for the living fraction was the greatest in April in both the natural and the thinned forests (+0.122 and +3.946 $g/m^2/day$, respectively). The productivity values of the dead fraction in the natural forest changed between —0.360 and 0.050 $g/m^2/day$ in the closed forest, and again between —1.403 and +1.238 $g/m^2/day$ in the thinned forest. The greatest daily root phytomass increase in the closed forest was +0.131 $g/m^2/day$, and in the open area +9.181 $g/m^2/day$.

The turnover rate of the above-ground living fraction is lower than that in the case of *Dactylis polygama* (88% and 75%, respectively). The turn-

over rate of the above-ground dead fraction changes also around 50%, in both areas and so it is nearly identical with that of the underground phytomass (44% and 58%, respectively). Accordingly the turnover time of the latter fractions is about 2 years.

Table 6

Productivity values of the phytomass fractions in Poa nemoralis (g/m²/day) in closed (A) and selected (B) forests

A

	Above-ground fractions		Underground fraction
	living	dead	
9.4—30.4 21	+0.122	—0.031	—0.087
30.4—26.5 26	+0.099	+0.050	+0.131
26.5—18.6 23	+0.115	—0.004	—0.028
18.6—11.7 23	—0.160	—0.036	—0.001
11.7—12.8 32	+0.008	+0.026	+0.036
12.8—17.9 36	—0.025	—0.004	—0.140
17.9—22.10 35	—0.011	+0.020	—0.012

B

	Above-ground fractions		Underground fraction
	living	dead	
9.4—30.4	+3.946	+1.230	+9.181
30.4—26.5	+1.693	—1.215	—5.547
26.5—18.6	—1.769	+0.316	—4.608
18.6—11.7	+0.989	—1.403	+0.186
11.7—12.8	+1.674	+1.120	+2.772
12.8—17.9	—2.240	—0.400	—1.535
17.9—22.10	+0.050	+1.238	—0.428

The root importance indices, calculated for the various samplings, changed similarly in both areas during the vegetation period. Root importance is the greatest in springtime also in this species. In the further samplings, we obtained values greater than 50% only in a few cases (Table 7).

Table 7

Changes in the root importance indices of Poa nemoralis in closed (A) and selected (B) forests

Sampl-ing	9.4	30.4	26.5	18.6	11.7	12.8	17.9	22.10
A (%)	64.37	53.96	51.80	45.82	54.85	54.55	45.38	43.45
B (%)	61.82	62.76	51.60	43.35	44.96	46.43	49.77	43.33

Summary

A portion of about 10 ha of a homogeneous stand of *Quercetum petraeae-cerris* forest ("Sikfőkút Project") was selected by foresters in 1973. About 3/4 of the trees were cut (Figs 3 and 4) as well as rich shrub layer of the forest. In this area and in the adjacent we examined the structural and production changes parallel in the two dominant species of the herbaceous layer (*Dactylis polygama, Poa nemoralis*) during 1975. We intended to observe the effects of the increased quantity of radiation (changed microclimate) and the abundant

Fig. 3. Section of the *Quercetum petraeae-cerris* forest in the Sikfőkút Project research area, Photo: P. Jakucs

anorganic substances lying partly unused in the soil on the herbaceous layer which had been left relatively undisturbed.

Our results show that the number of individuals of the herbaceous species, and their cover value, did saliently increase immediately after the intervention. While in the natural forest the coverage of the herbaceous layer was 31%, it increased above 200% in the selected forest. Similarly, great increase was measured also in the case of the specimen. The quantity of phytomass and production, in the case of the fractions of the two test plants increased to 10—33 folds. While the total yearly production of Poa nemoralis in the closed forest was, for example, 180 kg/ha in the selected forest, this increased to 5983 kg/ha (increased 33 times!).

The results show that in the forest, abruptly deprived of its foliage and shrub layer, the herb layer attempts to take over part of the turnover role of the organic matter in the years after the intervention. Owing to this, its phytomass and production abruptly increase to their manyfold. If in the later years the powerful shooting and regeneration of the trees and shrubs start, they probably regain this role from the herbaceous layer, thus creating gradually the specific turnover of the forest. If on the other hand — owing to

Fig. 4. Section of the selected forest stand adjacent to the research area. Photo: A. HEVESI

some reason — the reforestation does not ensure, the herbaceous species, which otherwise have an ecological demand for a closed forest, would gradually be forced back and yield ground for indifferent or for ubiguitous weed species. The soil would rapidly become poor in nutrient supply, homogenized and qualitatively devaluated.

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NICHE STUDIES ON SOME PLANT SPECIES OF A GRASSLAND COMMUNITY. II

SEASONAL NICHE DYNAMIC

By

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In the first publication, the authors summarized the results of their investigations carried out in the summer of 1976, by comparing the values obtained on the basis of various niche-measurements. The present study proposes an analysis of the examinations made in the autumn of 1976, then a comparison between the summer and autumn results. The autumn measurements were also carried out with regard to two niche axes (the soil moisture content and the depths of maximum root mass, in connection with space utilization) and are related to 9 species.

In the soil moisture content axis, the niche breadth of *Festuca vaginata*, predominating in the association, is the greatest both in summer and autumn. The niche breadth fluctuation of summer and autumn is stronger in the root-depth axis than in the other one. In the case of a good water supply of the soil in the autumn, the value of the average overlap increases; it is not likely, however, that this would express the increasing competition.

In the two-dimensional niche space (the combinations of the categories of the two factors), all the overlap indices result in a lower value than if considered separately on the various factor axes. According to the community matrix, the community effect is the greatest in relation to the species (*Festuca*) constituting the community. The adventicious *Cynodon* has the greatest species effect. The two kinds of effect are under the influence of strong seasonal fluctuation in the case of most of the species. In the two-dimensional niche space, the ecological isolation of *Fumana procumbens* is of the greatest extent: it has no effect on the community, nor has the community on it.

In our preceding publication, after a general introduction and a comparison between, the niche indices (FEKETE et al., 1977), we summarized our niche investigations carried out in summer, 1976 (June 8). In our present paper we describe our autumn niche investigations and compare the summer and autumn results (September 9, 1976).

The examinations were made in the same area, with identical methods, as has been described in our preceding paper. The species examined were also identical (*Festuca vaginata, Medicago minima, Thymus sp., Euphorbia seguieriana, Carex stenophylla, Fumana procumbens, Equisetum ramosissimum, Cynodon dactylon, Centaurea arenaria*) with one exception, namely *Minuartia* did occur that we had to leave it out of our investigations.

The categories of soil moisture content and root depth, as well as the frequency of species in the various categories, are given in Tables 1—3 (3 data

Table 1

The frequency of species in soil moisture categories

Species \ mS	0.4–0.7	0.8–1.1	1.2–1.5	1.6–1.9	2.0–	Sum
Festuca	8	10	6	4	0	28
Medicago	2	8	5	2	0	17
Thymus	1	7	4	2	0	14
Euphorbia	0	1	6	5	1	13
Carex	0	3	5	3	0	11
Fumana	0	0	3	6	1	10
Equisetum	1	0	3	5	0	9
Cynodon	0	0	3	4	1	8
Centaurea	1	0	3	2	1	7
Sum	13	29	38	33	4	117

Table 2

The frequency of species in root depth categories

Species \ cm	2.0–3.9	4.0–5.9	6.0–7.9	8.0–9.9	10.0–	Sum
Festuca	13	12	2	1	0	28
Medicago	13	3	2	0	0	18
Thymus	11	2	1	0	0	14
Euphorbia	0	6	3	3	1	13
Carex	7	4	1	0	0	12
Fumana	0	1	2	4	4	11
Equisetum	1	2	2	3	1	9
Cynodon	0	1	5	1	1	8
Centaurea	1	1	3	2	0	7
Sum	46	32	21	14	7	120

were excluded of the soil moisture content measurements because they were not reliable).

We applied the evenness function, HORN index, the non-weighted and the weighted and the weighted SCHOENER index, as well as LEVINS's formulas; their symbols are identical with those used in the preceding paper.

In addition, we also present the "*d*" values and the result of the *D*-analysis.

Table 3

The frequency distribution of the species in the categories of soil moisture and root depth

mS/cm → / Species ↓	0.4–0.79					0.8–1.19					1.20–1.59					1.60–1.99					2.0–				
	2–3.9	4–5.9	6–7.9	8–9.9	10–	2–3.9	4–5.9	6–7.9	8–9.9	10–	2–3.9	4–5.9	6–7.9	8–9.9	10–	2–3.9	4–5.9	6–7.9	8–9.9	10–	2–3.9	4–5.9	6–7.9	8–9.9	10–
Festuca	6	2				6	4				1	5				1	1	2							
Medicago	1	1				6	1	1			3		1	1		1	1								
Thymus	1					6	1				3	1				1		1							
Euphorbia							1					3	2	1			2	1	1	1				1	
Carex						1	2				4	1				1	1	1							
Fumana												1		2				2	2	2					1
Equisetum	1												1	1	1		2	1	2						
Cynodon												1	2					3	1						1
Centaurea	1											1	2					1	1					1	
Sum	10	3				19	9	1			11	13	8	5	1	4	7	12	7	3				2	2

The results of the autumn examinations

Niche breadth

Soil moisture content

On the basis of all indices, the greatest value of niche breadth belongs in *Festuca* (Table 4), and again the smallest in *Fumana*. The niche breadth of *Equisetum* and *Cynodon* is narrow, too.

Table 4

Niche breadth
Soil moisture

Species	C_i; w	H_i	B_i
Festuca	0.9554 (1)	0.8287 (1)	3.6298 (1)
Medicago	0.9272 (2)	0.7568 (3)	2.9797 (3)
Thymus	0.9055 (3)	0.7276 (4)	2.8003 (5)
Euphorbia	0.8686 (5)	0.6952 (5)	2.6831 (6)
Carex	0.8859 (4)	0.6630 (6)	2.8145 (4)
Fumana	0.7231 (9)	0.5580 (9)	2.1739 (9)
Equisetum	0.7882 (7)	0.5821 (8)	2.3143 (8)
Cynodon	0.7318 (8)	0.6054 (7)	2.4612 (7)
Centaurea	0.8620 (6)	0.7935 (2)	3.2658 (2)

In parentheses the rank numbers.

Root depth

The greatest niche breadth (in all three indices) was unambiguously found in *Equisetum* (Table 5). In the other cases, the situation is not so unequivocal. It appears that *Thymus* and *Medicago* possess here the narrowest niche breadth.

Table 5

Niche breadth
Root depth

Species	C_i; w	H_i	B_i
Festuca	0.8555 (6)	0.6379 (6)	2.4655 (5)
Medicago	0.8490 (7)	0.4833 (8)	1.7803 (8)
Thymus	0.8468 (8)	0.4076 (9)	1.5557 (9)
Euphorbia	0.8599 (5)	0.7648 (4)	3.0731 (4)
Carex	0.8620 (4)	0.5515 (7)	2.1820 (7)
Fumana	0.8772 (3)	0.7851 (3)	3.2712 (2)
Equisetum	0.9793 (1)	0.9462 (1)	4.2644 (1)
Cynodon	0.8295 (9)	0.6670 (5)	2.2857 (6)
Centaurea	0.9380 (2)	0.7935 (2)	3.2658 (3)

In parentheses the rank numbers.

Combination of soil moisture content and root depth

In the case of combining the two characteristics, we calculated only with non-weighted values (Table 6). The niche breadth of *Euphorbia* is the greatest, that of *Cynodon* the smallest (cf. Fig. 1).

Table 6

Niche breadth
The combination of soil moisture and root depth

Species	H_i	B_i
Festuca	0.6151 (3)	6.396 (2)
Medicago	0.6234 (2)	5.556 (5.5)
Thymus	0.5081 (8)	3.922 (9)
Euphorbia	0.6518 (1)	7.299 (1)
Carex	0.5492 (5)	4.878 (7)
Fumana	0.5431 (6)	5.556 (5.5)
Equisetum	0.5869 (4)	6.329 (3)
Cynodon	0.4642 (9)	3.968 (8)
Centaurea	0.5430 (7)	6.173 (4)

In parentheses the rank numbers.
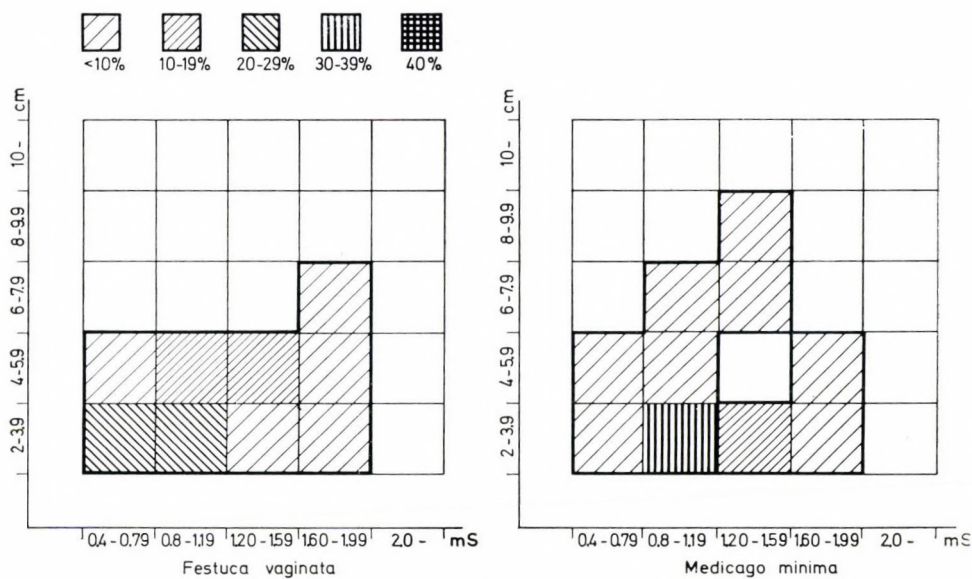
Fig. 1a–b

Fig. 1. Position of the species in the system of co-ordinates formed by the soil moisture and root depth axes. Hatching pattern indicates frequency. For the range of categories see figure of *Festuca vaginata*
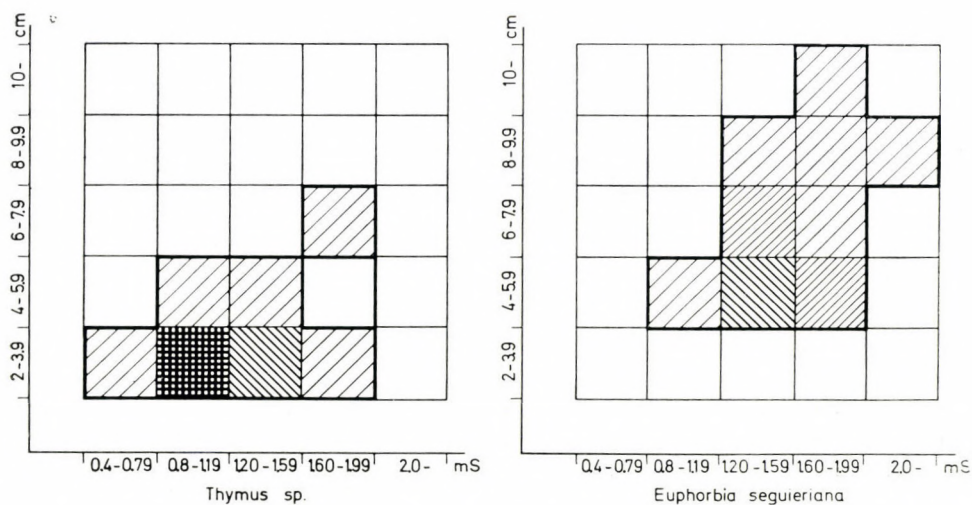
Fig. 1c–d
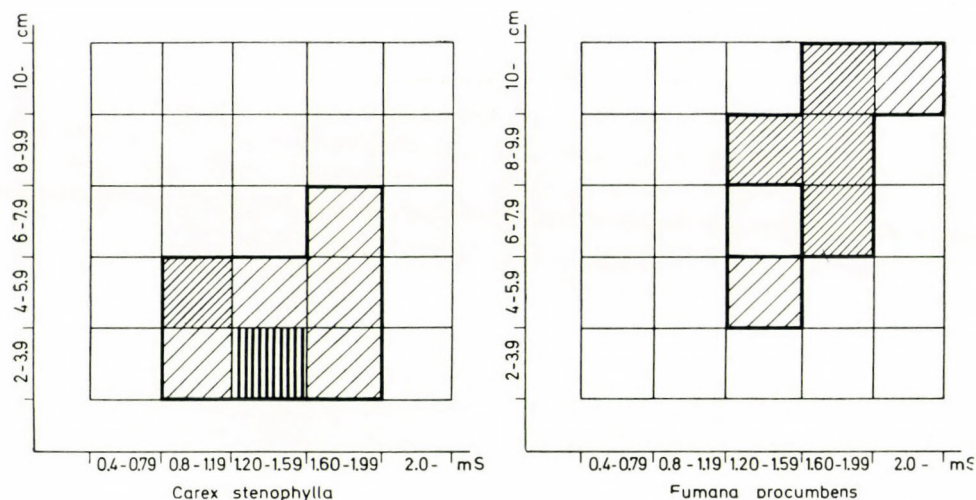
Fig. 1e—f

The sequence appearing from combining the two characteristics shows hardly any similarity to that obtained in the case of the separate characteristics ($r_{\text{rank}} = 0.65$ combinations — soil moisture content; $r_{\text{rank}} = -0.13$ combinations — root depth). *Euphorbia* lies in around the middle of the rank with regard to both the soil moisture content and the root depth; *Cynodon* is fairly near to *Euphorbia* (see column H_i in Tables 4 and 5). No special weight can be attributed to any of the characteristics.
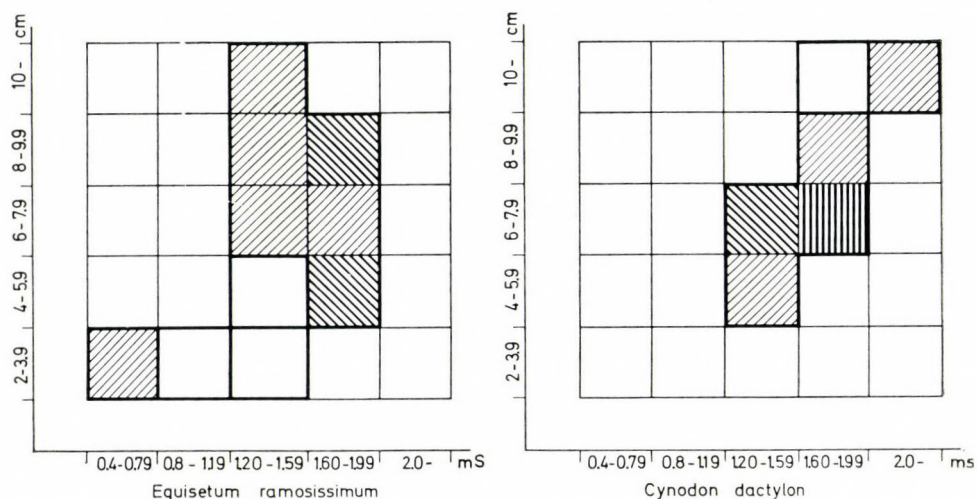
Fig. 1g—h
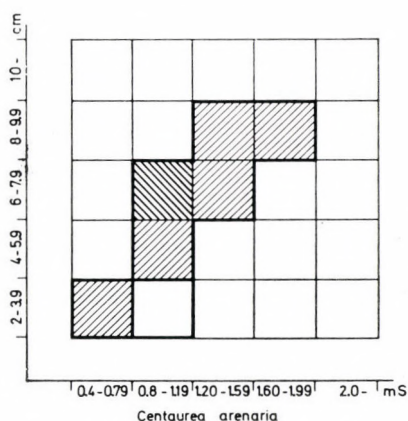
Fig. 1i.

Niche overlap

Soil moisture content

According to R_{hi} and d, the greatest overlap value was shown by the species pair *Medicago-Thymus*, while according to the C_{hi} and $C_{hi;w}$ indices by the species pair *Cynodon-Fumana*. The minimal overlap, according to C_{hi}; $C_{hi;w}$ and d, appeared in the species pair *Medicago-Fumana*, while according to the R_{hi} measure in the species pair *Medicago-Equisetum* (Tables 7, 8 and 9).

Table 7

Niche breadth and overlap values
Soil moisture

Species	*Festuca*	*Medicago*	*Thymus*	*Euphorbia*	*Carex*	*Fumana*	*Equisetum*	*Cynodon*	*Centaurea*
Festuca	0.8287	0.9643	0.9429	0.6970	0.8354	0.5689	0.7332	0.5912	0.7244
Medicago		0.7568	0.9947	0.7262	0.8924	0.5502	0.5080	0.5814	0.6885
Thymus			0.7276	0.7452	0.9130	0.5692	0.6726	0.5963	0.6688
Euphorbia				0.6952	0.9135	0.9332	0.8506	0.9529	0.8729
Carex					0.6630	0.7584	0.7691	0.7789	0.7198
Fumana						0.5580	0.8931	0.9927	0.8808
Equisetum							0.5821	0.8798	0.8877
Cynodon								0.6054	0.9035
Centaurea									0.7935

In the main diagonal the H_i values, in the semimatrix the R_{hi} values.

Table 8

Niche breadth and overlap values
Soil moisture

Species	*Festuca*	*Medicago*	*Thymus*	*Euphorbia*	*Carex*	*Fumana*	*Equisetum*	*Cynodon*	*Centaurea*
Festuca	*0.9554*	0.8065	0.7850	0.4335	0.6295	0.3570	0.4680	0.3570	0.4995
Medicago	0.8191	*0.9272*	0.8690	0.4880	0.6840	0.4115	0.5225	0.4115	0.5290
Thymus	0.7914	0.9536	*0.9055*	0.5055	0.7015	0.4290	0.5000	0.4290	0.4990
Euphorbia	0.3806	0.3701	0.3827	*0.8686*	0.8040	0.7615	0.7175	0.8365	0.7910
Carex	0.7348	0.7479	0.7605	0.6222	*0.8859*	0.5725	0.6055	0.6975	0.7010
Fumana	0.1462	0.1357	0.1482	0.7123	0.3735	*0.7231*	0.8560	0.9000	0.6855
Equisetum	0.3234	0.2436	0.2137	0.6809	0.3802	0.8168	0.7882	0.8330	0.7295
Cynodon	0.1469	0.1364	0.1490	0.7458	0.3885	0.9310	0.8235	*0.7318*	0.7855
Centaurea	0.4119	0.2428	0.2243	0.6535	0.3876	0.5367	0.7092	0.6890	*0.8620*

In the main diagonal the $C_{i;w}$ values; in the upper semimatrix the C_{hi} and in the lower semimatrix the $C_{hi;w}$ values.

Table 9

The euclidean distance (d) between species

Species	*Festuca*	*Medicago*	*Thymus*	*Euphorbia*	*Carex*	*Fumana*	*Equisetum*	*Cynodon*	*Centaurea*
Festuca		0.657	0.445	0.928	0.713	1.075	0.896	1.045	0.897
Medicago	0.598		0.098	0.877	0.542	1.091	1.035	1.041	0.947
Thymus	0.556	0.073		0.874	0.533	1.073	1.033	1.030	0.974
Euphorbia	0.879	1.233	1.280		0.392	0.422	0.407	0.263	0.328
Carex	0.204	0.270	0.334	1.050		0.716	0.670	0.615	0.583
Fumana	1.276	1.352	1.372	0.870	1.325		0.234	0.170	0.566
Equisetum	0.931	1.103	1.117	0.515	1.019	0.582		0.270	0.503
Cynodon	1.229	1.279	1.328	0.851	1.257	0.903	0.780		0.273
Centaurea	1.021	1.076	1.124	0.732	1.053	0.850	0.463	0.485	

In the upper semimatrix the values of soil moisture, in the lower semimatrix the values of root depth.

Considering the average overlap values (on the basis of R_{hi}, C_{hi}, $C_{hi;w}$ and d; see Table 10), *Euphorbia* stands at the first place, *Carex* is near to it; the overlap of these two species is great with the other species. At the other end of the series we find *Festuca* and *Medicago*, the overlap of which is small with the other species. It is interesting to observe that *Fumana* stands at the sixth place according to all the measures.

The distribution of the C_{hi}, $C_{hi;w}$, R_{hi} and d indices is given in Table 11. Index C_{hi} shows an almost identically great similarity in the 0.7 and 0.4 classes,

Table 10

Average niche overlap values of species
Soil moisture content

Species	C_{hi}	$C_{hi;w}$	R_{hi}	d
Festuca	0.5420 (9)	0.4693 (7)	0.7571 (8)	0.8320 (9)
Medicago	0.5902 (7)	0.4561 (8)	0.7382 (9)	0.7860 (8)
Thymus	0.5897 (8)	0.4529 (9)	0.7628 (7)	0.7575 (7)
Euphorbia	0.6672 (2)	0.5685 (1)	0.8364 (1)	0.5614 (1)
Carex	0.6744 (1)	0.5494 (2)	0.8225 (2)	0.5955 (3)
Fumana	0.6216 (6)	0.4750 (6)	0.7683 (6)	0.6684 (6)
Equisetum	0.6540 (4)	0.5239 (3)	0.7742 (5)	0.6310 (4)
Cynodon	0.6562 (3)	0.5012 (4)	0.7846 (4)	0.5883 (2)
Centaurea	0.6525 (5)	0.4818 (5)	0.7933 (3)	0.6338 (5)

In parentheses the rank numbers.

while $C_{hi;w}$ in the 0.7 and 0.3 classes. The R_{hi} values are frequent in the 0.9—0.7 classes, while among the d values those belonging in 1.0 classes are the most frequent. It is remarkable that in the case of the index R_{hi} the distribution of the values is the narrowest, it is restricted to five classes; further that in the case of the indices C_{hi}, $C_{hi;w}$ and R_{hi} we did not observe a definite peak, while the d values showed a peak.

Table 11

Distribution of niche overlap and d values

Category	1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
Soil moisture															
C_{hi}						1	6	8	5	5	9	2			
$C_{hi;w}$						2	3	7	4	1	1	8	4	6	
R_{hi}						9	8	8	4	7					
Root depth															
C_{hi}						1	2	5	3	6	3	6	6	4	
$C_{hi;w}$						4	4	3	5	1	6	2	6	5	
R_{hi}						8	7	2	5	4	3	4	3		
Combinations															
C_{hi}								2	0	5	8	4	6	9	2
R_{hi}							2	4	6	2	6	5	8	3	
d values															
soil moisture					8	3	4	2	3	5	3	2	4	1	1
root depth		4	6	3	5	2	4	2	0	4	2	1	2	0	1
combinations		10	7	3	3	6	3	3	0	0	0	1			

The species and community effects calculated on the basis of the community matrix (Tables 12 and 13) resulted in different ranks, as had been expected. Considering the competition concerning soil moisture content, the plant community has a great effect on *Centaurea*, and has hardly any effect on *Fumana* and *Thymus*. In this competition, *Euphorbia* and *Equisetum* have great effect on the other species, while *Festuca* and *Medicago* have only a very weak effect.

Table 12

Community matrix
Soil moisture

α_{ih} \ α_{hi}	*Festuca*	*Medicago*	*Thymus*	*Euphorbia*	*Carex*	*Fumana*	*Equisetum*	*Cynodon*	*Centaurea*
Festuca	*3.6298*	1.0218	1.0185	0.6581	0.8483	0.5445	0.6628	0.5510	0.6298
Medicago	0.8388	*2.9797*	1.0265	0.6469	0.8763	0.4732	0.5256	0.5039	0.5259
Thymus	0.7858	0.9647	*2.8003*	0.6309	0.8547	0.4803	0.5113	0.5001	0.4859
Euphorbia	0.4865	0.5825	0.6045	*2.6831*	0.9005	1.0113	0.9860	1.0062	0.8551
Carex	0.6578	0.8278	0.8590	0.9446	*2.8145*	0.8444	0.8528	0.8635	0.7675
Fumana	0.3261	0.3452	0.3728	0.8193	0.6522	*2.1739*	0.9422	0.9239	0.6833
Equisetum	0.4226	0.4082	0.4226	0.8505	0.7012	1.0030	*2.3143*	0.9322	0.7348
Cynodon	0.3736	0.4162	0.4396	0.9230	0.7551	1.0460	0.9914	*2.4612*	0.7910
Centaurea	0.5666	0.5764	0.5666	1.0408	0.8906	1.0265	1.0369	1.0496	*3.2658*

In the main diagonal the B_i values.

Table 13

The species and the community effects

Species	Species effect		Community effect	
	Root depth	Soil moisture content	Root depth	Soil moisture content
Festuca	0.5937 (4)	0.5572 (9)	0.6159 (3)	0.7418 (4)
Medicago	0.6035 (2)	0.6428 (8)	0.4551 (6)	0.6771 (7)
Thymus	0.6045 (1)	0.6638 (7)	0.3911 (8)	0.6517 (8)
Euphorbia	0.5252 (6)	0.8143 (1)	0.5711 (5)	0.8041 (3)
Carex	0.6008 (3)	0.8098 (3)	0.5602 (4)	0.8272 (2)
Fumana	0.3802 (9)	0.8036 (4)	0.4091 (7)	0.6331 (9)
Equisetum	0.4980 (8)	0.8136 (2)	0.8159 (1)	0.6844 (6)
Cynodon	0.5198 (7)	0.7913 (5)	0.3855 (9)	0.7170 (5)
Centaurea	0.5551 (5)	0.6842 (6)	0.6769 (2)	0.8442 (1)

In parantheses the rank numbers.

Root depth

Considering either of the indices, the maximum overlap appears in the *Medicago-Thymus* species pair. The minimum overlap value was experienced in the species pair *Thymus-Fumana*, with the exception of the $C_{hi;w}$ index, where the species pair *Thymus-Euphorbia* showed a minimum value (Tables 14 and 15).

Table 14

The niche breath and overlap
Root depth

Species	*Festuca*	*Medicago*	*Thymus*	*Euphorbia*	*Carex*	*Fumana*	*Equisetum*	*Cynodon*	*Centaurea*
Festuca	0.6379	0.9192	0.9054	0.6666	0.9518	0.3793	0.6999	0.4772	0.7081
Medicago		0.4833	0.9953	0.4313	0.9727	0.2609	0.5667	0.4011	0.6218
Thymus			0.4076	0.3609	0.9604	0.2227	0.5277	0.3199	0.5686
Euphorbia				0.7648	0.5188	0.8167	0.9009	0.8455	0.8028
Carex					0.5515	0.2601	0.6096	0.3867	0.6210
Fumana						0.7851	0.8693	0.8180	0.7125
Equisetum							0.9462	0.8281	0.9144
Cynodon								0.6670	0.8287
Centaurea									0.7935

In the main diagonal the H_i values, in the semimatrix the R_{hi} values.

Table 15

The niche breadth and overlap values
Root depth

Species	*Festuca*	*Medicago*	*Thymus*	*Euphorbia*	*Carex*	*Fumana*	*Equisetum*	*Cynodon*	*Centaurea*
Festuca	*0.8555*	0.7020	0.6780	0.5355	0.8685	0.1980	0.4405	0.2320	0.3925
Medicago	0.8509	*0.8490*	0.9360	0.2775	0.8335	0.2020	0.3890	0.2360	0.3965
Thymus	0.8300	0.9730	*0.8468*	0.2135	0.7975	0.1620	0.3255	0.1960	0.3565
Euphorbia	0.2740	0.1310	0.1040	*0.8599*	0.4160	0.5795	0.7520	0.5575	0.6040
Carex	0.9153	0.9356	0.9135	0.8095	*0.8620*	0.1745	0.4170	0.2085	0.3690
Fumana	0.2541	0.2280	0.2028	0.7459	0.2230	*0.8772*	0.7165	0.5220	0.5575
Equisetum	0.4603	0.3715	0.3445	0.7362	0.4292	0.7924	*0.9793*	0.5820	0.7610
Cynodon	0.2155	0.1539	0.1268	0.6175	0.1844	0.6155	0.5620	*0.8295*	0.6785
Centaurea	0.4499	0.4003	0.4886	0.6537	0.4188	0.6455	0.8341	0.6123	*0.9380*

In the main diagonal the niche breadth values, $C_{i;w}$; in the right semimatrix the C_{hi} values and in the left semimatrix the $C_{hi;w}$ values.

With regard to the average overlap, *Euphorbia* stands at the first place, *Fumana* at the last one (Table 16). In the case of root depth no species can be found which could be given the same rank number in the case of the indices.

The distribution of the R_{hi} values shows a maximum (0.9) value (Table 11), which cannot be found in the case of the other indices. The C_{hi}, $C_{hi;w}$ and R_{hi} values occur in an almost identical domain.

The community effect, which has been calculated on the basis of the community matrix (Table 17), is unexpectedly high (Table 13). The community

Table 16

Average niche overlap values of species
Root depth

Species	C_{hi}	$C_{hi;w}$	R_{hi}	d
Festuca	0.5058 (4)	0.5312 (4)	0.7134 (3)	0.8367 (3)
Medicago	0.4965 (5)	0.5055 (6)	0.6461 (6)	0.8730 (5)
Thymus	0.4581 (7)	0.4979 (7)	0.6076 (8)	0.8980 (6)
Euphorbia	0.4919 (6)	0.5089 (5)	0.6679 (4)	0.9262 (7)
Carex	0.5105 (3)	0.6036 (1)	0.6601 (5)	0.8140 (2)
Fumana	0.3890 (9)	0.4634 (8)	0.5424 (9)	1.0662 (9)
Equisetum	0.5479 (1)	0.5663 (2)	0.7396 (1)	0.8137 (1)
Cynodon	0.4015 (8)	0.3860 (9)	0.6131 (7)	1.0140 (8)
Centaurea	0.5144 (2)	0.5629 (3)	0.7222 (2)	0.8505 (4)

In parentheses the rank numbers.

Table 17

Community matrix
Root depth

α_{ih} \ α_{hi}	*Festuca*	*Medicago*	*Thymus*	*Euphorbia*	*Carex*	*Fumana*	*Equisetum*	*Cynodon*	*Centaurea*
Festuca	*2.4655*	1.0224	1.0629	0.5486	1.0345	0.1600	0.4305	0.2532	0.4152
Medicago	0.7383	*1.7803*	1.0668	0.1827	0.8654	0.0630	0.2528	0.1608	0.3108
Thymus	0.6707	0.9322	*1.5557*	0.1282	0.7964	0.0404	0.2099	0.0972	0.2540
Euphorbia	0.6838	0.3153	0.2532	*3.0731*	0.5317	0.6017	0.7354	0.7388	0.7093
Carex	0.9156	1.0607	1.1170	0.3775	*2.1820*	0.0991	0.3434	0.2045	0.3637
Fumana	0.2123	0.1158	0.0851	0.6405	0.1485	*3.2712*	0.7269	0.7062	0.6372
Equisetum	0.7446	0.6055	0.5753	1.0205	0.6712	0.9475	*4.2644*	0.9475	1.0154
Cynodon	0.2347	0.2064	0.1429	0.5495	0.2142	0.4935	0.5079	*2.2857*	0.7349
Centaurea	0.5500	0.5702	0.5333	0.7538	0.5444	0.6362	0.7776	1.0500	*3.2658*

In the main diagonal the B_i values.

has a strong effect on *Equisetum*, while hardly any influence on *Cynodon* and *Thymus*. *Thymus* and *Medicago* have great effect on the other species, and again the effect of *Fumana* and *Equisetum* is very small.

Combination of the soil moisture content and the root depth

The overlap is the smallest in the species pair *Medicago-Fumana*, while again it is the greatest in the species pair *Medicago-Thymus* (Tables 18 and 19); an exception is the R_{hi} value according to which the overlap is the greatest between the *Festuca* and *Thymus*.

Table 18

Niche breadth and overlap values
Combination of root depth and soil moisture content

Species	*Festuca*	*Medi-cago*	*Thymus*	*Euphor-bia*	*Carex*	*Fumana*	*Equi-setum*	*Cynodon*	*Centau-rea*
Festuca	*0.6151*	0.6905	0.8198	0.4526	0.7135	0.2490	0.3923	0.3170	0.4260
Medicago	0.4925	*0.6234*	0.7794	0.3211	0.6574	0.1073	0.3618	0.1218	0.2275
Thymus	0.5710	0.7065	*0.5081*	0.2686	0.8001	0.4044	0.1801	0.2521	0.3111
Euphorbia	0.3625	0.2350	0.2135	*0.6517*	0.4504	0.4186	0.6292	0.6204	0.7090
Carex	0.5035	0.4430	0.5895	0.3450	*0.5492*	0.2268	0.2395	0.2811	0.2305
Fumana	0.1710	0.0585	0.1430	0.4075	0.1815	*0.5431*	0.5015	0.6508	0.4520
Equisetum	0.2185	0.2360	0.1435	0.4960	0.1820	0.4225	*0.5868*	0.5163	0.6012
Cynodon	0.1960	0.0585	0.1430	0.4325	0.1815	0.5250	0.3475	*0.4642*	0.7521
Centaurea	0.3565	0.1170	0.2135	0.5270	0.2525	0.4570	0.4760	0.7050	*0.5429*

In the main diagonal the H_i values; in the upper semimatrix the R_{hi} and in the lower semimatrix the C_{hi} values.

Table 19

The euclidean distance (d) between species
Combination of soil moisture content and root depth

Species	*Medi-cago*	*Thymus*	*Euphor-bia*	*Carex*	*Fumana*	*Equi-setum*	*Cynodon*	*Centau-rea*
Festuca	0.8321	0.7431	1.0671	1.0150	1.2724	1.2255	1.2272	1.1053
Medicago		0.3676	1.2870	0.8895	1.3677	1.2724	1.3648	1.3135
Thymus			1.3058	0.8360	1.3416	1.3576	1.3104	1.3104
Euphorbia				1.1544	0.9585	0.9184	0.9096	0.7810
Carex					1.3104	1.2912	1.2649	1.3166
Fumana						0.9768	0.9064	1.1020
Equisetum							1.0145	0.9437
Cynodon								0.7071

Considering the average overlap value, the values according to a C_{hi}, R_{hi} and d order resulted in an identical rank number in *Equisetum* and *Cynodon*. At the beginning of the series there appear *Euphorbia* and *Festuca;* the average overlap of these is great, while *Fumana* stands at the end of the series (Table 20).

Table 20

The average niche overlap values of species
Combination of soil moisture content and root depth

Species	C_{hi}	R_{hi}	d
Festuca	0.3589 (3)	0.5076 (1)	1.0609 (2)
Medicago	0.2934 (9)	0.4083 (8)	1.0868 (5)
Thymus	0.3404 (4)	0.4769 (3)	1.0715 (3)
Euphorbia	0.3774 (2)	0.4837 (2)	1.0477 (1)
Carex	0.3348 (5)	0.4499 (5)	1.1347 (8)
Fumana	0.2958 (8)	0.3763 (9)	1.1543 (9)
Equisetum	0.3153 (7)	0.4277 (7)	1.1250 (7)
Cynodon	0.3236 (6)	0.4389 (6)	1.0881 (6)
Centaurea	0.3881 (1)	0.4637 (4)	1.0724 (4)

In respect of the distribution of the overlap and the d values (Table 11), the d-values gave a curve with one peak. In comparison with the distribution of the corresponding values of soil moisture content and root depth, the highest frequency of the C_{hi} and R_{hi} values shifted towards the lower class intervals, and the d values showed a similar tendency; here it must be taken into consideration that an increase in the d-value means a decrease in the overlap.

The community effect is the highest in the case of *Euphorbia*, the lowest in *Thymus* (Tables 21 and 22). The species effect is high in *Cynodon*, and low in *Fumana*.

The rank number (6 and 3) of two species, viz. *Carex* and *Centaurea*, were identical in the case of the community and species effect.

A D-analysis was carried with the same species and characteristics as were considered in our previous publication. The centre of the *Fumana*, *Euphorbia* and *Medicago* niche is at a great distance from that of the other species. The centres of *Euphorbia* and *Fumana* are near to each other. The distance between *Festuca* and *Medicago* is minimal (cf. Table 23).

Table 21

Community matrix
Combination of root depth and soil moisture content

a_{ih} \ a_{hi}	*Festuca*	*Medicago*	*Thymus*	*Euphorbia*	*Carex*	*Fumana*	*Equisetum*	*Cynodon*	*Centaurea*
Festuca	*6.369*	0.707	0.930	0.401	0.548	0.204	0.255	0.312	0.428
Medicago	0.617	*5.556*	1.117	0.156	0.650	0.067	0.150	0.083	0.139
Thymus	0.573	0.788	*3.922*	0.102	0.580	0.082	0.063	0.141	0.118
Euphorbia	0.460	0.204	0.190	*7.299*	0.409	0.606	0.613	0.781	0.803
Carex	0.420	0.571	0.722	0.273	*4.878*	0.132	0.146	0.220	0.127
Fumana	0.178	0.067	0.117	0.461	0.150	*5.556*	0.489	0.700	0.400
Equisetum	0.253	0.171	0.101	0.532	0.190	0.557	*6.329*	0.620	0.608
Cynodon	0.194	0.060	0.143	0.425	0.179	0.500	0.389	*3.968*	0.643
Centaurea	0.414	0.154	0.185	0.679	0.160	0.444	0.593	1.000	*6.173*

In the main diagonal the B_i values.

Table 22

The species and community effect
Combination of soil moisture content and root depth

Species	Species effect	Community effect
Festuca	0.389 (4)	0.473 (2)
Medicago	0.340 (7)	0.372 (5)
Thymus	0.438 (2)	0.306 (9)
Euphorbia	0.379 (5)	0.508 (1)
Carex	0.358 (6)	0.326 (6)
Fumana	0.324 (9)	0.320 (7)
Equisetum	0.337 (8)	0.379 (4)
Cynodon	0.482 (1)	0.317 (8)
Centaurea	0.408 (3)	0.454 (3)

Table 23

Results of D-analysis

Species	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*
Festuca	0.143	0.357	1.605***	0.967***	0.228
Medicago		1.059***	1.333***	0.889**	0.206
Thymus			1.593***	0.989***	0.235
Fumana				0.581	1.383***
Euphorbia					0.806*

* significant at 5% level
** significant at 1% level
*** significant at 0.1% level

Summer—autumn changes

Soil moisture content

On the basis of the summer and the autumn investigations, the niche breadth of *Festuca* is the greatest in relation to soil moisture content. *Festuca*, the dominant species, can be found in any of the categories of soil moisture content; it is only in the domain greater than 2.0 mS where it does not appear. After it, *Medicago* and *Thymus* follow, and *Centaurea*. The niche breadth of *Cynodon*, *Fumana* and *Equisetum* is narrow both in summer and autumn. *Equisetum* and *Cynodon* in summer lie on the end of the axis which is opposite to *Fumana*. In autumn all three species are frequent in the high mS categories, the most frequent value is in the same category. Their occurrence is virtually restricted to two-three categories both in summer and autumn.

In the summer investigations, the overlap value was high between *Festuca* and *Carex*, according to the R_{hi} and C_{hi} index numbers; and again according to the *d*-value it was great between *Carex* and *Equisetum*. In autumn, according to the R_{hi} and *d*-values, the overlap is great between *Medicago* and *Thymus*, while according to the C_{hi} value it is great between *Cynodon* and *Fumana*. In summer, the lowest overlap values were experienced between *Fumana* and *Equisetum*. On the basis of autumn measurements, the overlap value is small between *Medicago* and *Equisetum* (the value of R_{hi}) and between *Medicago* and *Fumana* (C_{hi} and *d* values).

In examining the average overlap order of the species, non-reliable negative correlations can be detected in the case of the various indices between the summer and autumn ranks. If the rank numbers belonging in the various

Table 24

The rank of average niche overlap values
Soil moisture

Species	Summer			Fall		
	C_{hi}	R_{hi}	d	C_{hi}	R_{hi}	d
Festuca	1	1	1	9	8	9
Medicago	5	4	5	7	9	8
Thymus	3	3	2	8	7	7
Euphorbia	8	7	8	2	1	1
Carex	2	2	3	1	2	3
Fumana	9	9	9	6	6	6
Equisetum	7	8	7	4	5	4
Cynodon	4	5	4	3	4	2
Centaurea	6	6	6	5	3	5

index categories are added up (Table 24), and their sum is ranked, naturally a negative correlation is received between the summer and the autumn ranks ($r_{\text{rank}} = -0.31$). In summer, *Festuca* had a high average overlap value in relation to the other species, while by the autumn the value of the same species was the lowest. *Festuca*, as it were, has changed place with *Euphorbia*.

The frequency distribution of the overlap values (Table 25) in the summer and the autumn investigations can be considered identical in the case of indices R_{hi} and d ($\chi^2 = 2.9868$, $df: 4$; and $\chi^2 = 6.7971$, $df: 7$). In the case of the C_{hi} indices, the frequency of the summer and autumn overlap values differs ($\chi^2 = 11.3088$, $df: 5$).

Table 25

The distribution of overlap values
Soil moisture

Category		1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
C_{hi}	summer							3	5	9	3	5	7	2	1	1
	fall						1	6	8	5	5	9	2	0	0	0
$C_{hi;w}$	summer							2	3	9	6	1	5	5	3	2
	fall						2	3	7	4	1	1	8	4	6	0
R_{hi}	summer						5	10	5	6	5	3	1	1		
	fall						9	8	8	4	7	0	0	0	0	0
d	summer		1	5	2	7	1	2	3	4	2	4	3	1	1	
	fall					8	3	4	2	3	5	3	2	4	1	1

The community effect is great in summer in the case of *Cynodon* and *Equisetum*, and again in autumn in the case of *Centaurea* and *Carex*. *Fumana* appears at the end of the line both in summer and autumn (Table 26). From this it can be inferred that the other species have no influence on the competition of *Fumana* related to soil moisture content. *Festuca* has influence on the other species in summer, *Euphorbia* in autumn; thus, in this case, the species effect reflects the average overlap value. In summer, *Euphorbia* and *Fumana* have hardly any effect on the other species, in autumn the influence of *Festuca* and *Medicago* is minimal. The species and community effects of

Table 26

Species and community effect
Soil moisture, rank numbers

Species	Species effect		Community effect	
	Summer	Fall	Summer	Fall
Festuca	1	9	6	4
Medicago	5	8	5	7
Thymus	2	7	3	8
Euphorbia	8	1	9	3
Carex	3	3	4	2
Fumana	9	4	8	9
Equisetum	7	2	2	6
Cynodon	4	5	1	5
Centaurea	6	6	7	1

Medicago, *Euphorbia* and *Centaurea* were about identical in value. In autumn, besides *Medicago* and *Euphorbia*, *Thymus* and *Carex* have about identical species and community effect values.

Root depth

In the summer investigations, *Euphorbia* had the greatest niche breadth, in the autumn *Equisetum;* this latter had on the other hand, the almost narrowest breadth in summer. *Centaurea* occurred in merely category in summer, thus it showed the smallest breadth; in autumn this occurred with *Thymus*. The order of the species is different in summer and in autumn; no species can be found which would occupy the same or about the same rank both in summer and in autumn. At the autumn measurements the majority of the species shifted towards the smaller root depth categories (2—3 and 4—5 cm).

In the case of all overlap indices, it is between *Carex* and *Medicago* where the maximum overlap value is to be found in summer. Overlap is the greatest between *Medicago* and *Thymus* in autumn, in the case of all indices. The overlap value is minimum between *Fumana* and *Medicago*, *Fumana* and *Thymus*, *Fumana* and *Carex*, *Fumana* and *Centaurea* and *Fumana* and *Equisetum* in summer. The species pair *Thymus—Fumana* and that of *Thymus* and *Euphorbia* showed their minimum overlap in autumn. It is worthy of observation that *Medicago* overlaps with some of the species both in summer and in autumn to a great extent; the species pair *Thymus—Fumana* hardly overlapped in any of the two investigations. The overlap order of the 36 species pairs that can be formed shows a good agreement with one another both in summer

and in autumn, according to even several of the indices (positive significant rank correlations, cf. Table 34).

In the average overlap order, in summer, *Thymus* unambiguously takes the first place, then *Festuca* and *Medicago* follow. At the opposite end of the rank stand *Euphorbia*, *Centaurea* and *Fumana*. In autumn, *Equisetum* stands in the first place, then *Centaurea* follows, and again at the other end of the rank now stands *Thymus*, *Cynodon* and *Fumana* (Table 27). Between the

Table 27

The rank of average niche overlap values
Root depth

Species	Summer			Fall		
	C_{hi}	R_{hi}	d	C_{hi}	R_{hi}	d
Festuca	2	2	3	4	3	3
Medicago	3	3	2	5	6	5
Thymus	1	1	1	7	8	6
Euphorbia	7	7	7	6	4	7
Carex	5	5	5	3	5	2
Fumana	9	9	9	9	9	9
Equisetum	6	6	6	1	1	1
Cynodon	4	4	4	8	7	8
Centaurea	8	8	8	2	2	4

summer and autumn ranks (C_{hi}, R_{hi}) there is a non-reliable negative correlation, while between the ranks formed on the basis of d values there is a non-reliable positive correlation. After adding up the rank numbers belonging in the various index categories, and after ranking the detained sums, a non-reliable negative correlation appears between the summer and autumn ranks.

The frequency distribution of the overlap values (Table 28) can be considered as identical in the two investigations, with regard to all indices (C_{hi}, R_{hi} and d). The χ^2 values, in the corresponding order, are 6.6857, df : 6; 5.4738, df : 5; 5.8118, df : 7.

The community effect in summer is the greatest with *Thymus*, and again it is saliently high in *Equisetum* (Table 29). In the case of *Fumana*, the community effect is minimal in summer; no similarly great value, or one approximating this, could be experienced in autumn, when low values occurred with *Cynodon* and *Thymus*. The species effect was the greatest in *Equisetum* in summer, in *Thymus* in autumn; in *Fumana* it was minimal in both of the cases. *Fumana* has no influence on the other species in the competition for utilizing space (below ground), neither have the other species on *Fumana*.

Table 28

The distribution of overlap values
Root depth

Category		1.4	1.3	1.2	1.1	1.0	0.9	0.8	0.7	0.6	0.5	0.4	0.3	0.2	0.1	0.0
C_{hi}	summer						1	2	3	3	6	3	2	4	4	8
	fall						1	2	5	3	6	3	6	6	4	0
$C_{hi;w}$	summer							2	1	3	3	4	6	6	4	7
	fall						4	4	3	5	1	6	2	6	5	0
R_{hi}	summer						4	5	7	5	2	3	4	0	1	5
	fall						8	7	2	5	4	3	4	3	0	0
d	summer	5	2	3	4	2	6	3	3	1	2	2	2	0	1	0
	fall		4	6	3	5	2	4	2	0	4	2	1	2	0	1

Table 29

Species and community effect
Root depth, rank numbers

Species	Species effect		Community effect	
	Summer	Fall	Summer	Fall
Festuca	3	4	3	3
Medicago	6	2	4	6
Thymus	4	1	1	8
Euphorbia	8	6	6	5
Carex	7	3	5	4
Fumana	9	9	9	7
Equisetum	1	8	7	1
Cynodon	5	7	2	9
Centaurea	2	5	8	2

The community effect was identical in the case of *Festuca* and *Medicago* in summer, and again in that of *Thymus* and *Cynodon* in autumn. The species effect showed about identical values in the species in summer, with the exception of *Fumana* and *Euphorbia;* in autumn, *Fumana* (possibly *Equisetum*) was the exception.

Combination of root depth and soil moisture content

The order of niche breadths calculated on the basis of combinations is different in summer from that in autumn (Table 30; $r_{\text{rank}} = 0.5667$, $df: 7$). *Carex* occupied the same place both in summer and in autumn, in the middle of the series. At the beginning of the series there appear *Festuca* and *Euphorbia*, at the end of the series there stand *Equisetum* and *Cynodon*. From the average overlap orders it appears (Table 31) that the ranks formed according to any of the indices showed no agreement in respect of the sampling times. Forming the ranks on the basis of the three indices (R_{hi}, C_{hi} and d), the average overlap

Table 30

The rank of niche breadths (H_i) of species in summer and fall
Combination of soil moisture content and root depth

Species	Summer	Fall
Festuca	1	3
Medicago	5	2
Thymus	3	8
Euphorbia	2	1
Carex	4	4
Fumana	6	5
Equisetum	9	7
Cynodon	7	9
Centaurea	8	6

Table 31

The rank of average niche overlap values of species in summer and fall
Combination of soil moisture content and root depth

Species	C_{hi}		R_{hi}		d	
	Summer	Fall	Summer	Fall	Summer	Fall
Festuca	1	3	1	1	1	2
Medicago	4	9	4	8	5	5
Thymus	2	4	2	3	2	3
Euphorbia	7	2	7	2	7	1
Carex	3	5	3	5	3	8
Fumana	9	8	9	9	9	9
Equisetum	5	7	5	7	6	7
Cynodon	6	6	6	6	4	6
Centaurea	8	1	8	4	8	4

of *Festuca* is the greatest. *Festuca* had the greatest overlap value in summer, *Euphorbia* in autumn. *Fumana* was the last in order in all cases.

The summer and autumn distribution of the overlap frequencies calculated in the combinations (cf. Table 11) was significantly different in the case of the C_{hi} and R_{hi} indices ($\chi^2 = 12.2762$, *df* : 5; $\chi^2 = 13.4510$, *df* : 5), while in the case of *d* the two distributions can be considered as identical ($\chi^2 = 2.3332$, *df* : 5).

In summer, according to all three indices, the maximum overlap occurred in different species pairs; according to R_{hi}: *Festuca-Equisetum;* according to C_{hi}: *Cynodon-Equisetum;* on the basis of *d*: *Medicago-Thymus*. The minimal overlap appeared between *Fumana* and the following species, in all three index categories: *Medicago*, *Thymus*, *Equisetum* and *Centaurea*. According to *d*, the great overlap value of summer investigations, in the species pair *Medicago-*

Table 32

The rank of species by species and community effect in summer and fall
Combination of soil moisture content and root depth

Species	Species effect		Community effect	
	Summer	Fall	Summer	Fall
Festuca	4	4	1	2
Medicago	5	7	5	5
Thymus	6	2	2	9
Euphorbia	8	5	6	1
Carex	3	6	3	6
Fumana	9	9	9	7
Equisetum	1	8	7	4
Cynodon	2	1	4	8
Centaurea	7	3	8	3

Table 33

Results of D-analysis
Summer and fall

Species	*D* value
Festuca	1.3161***
Medicago	0.9655**
Thymus	1.6023***
Fumana	1.1140**
Euphorbia	3.2764***
Carex	1.3150**

Table 34

Rank correlation coefficients between summer and fall values of the various measures

Measure	df	Root depth	Soil moisture content	Combination of soil moisture content and root depth
H_i	7	—0.5833	0.4500	0.5667
$C_{i;w}$	7	—0.4500	0.5500	—
B_i	7	—0.6167	0.7167*	0.1833
C_{hi}	34	0.3515*	0.0916	0.2449
R_{hi}	34	0.5068***	0.0044	0.2430
α_{hi}	34	0.4474**	—0.0548	0.1910
α_{ih}	34	0.3277*	—0.0131	0.2748
d	34	0.4296***	—0.1583	0.2691

df = degree of freedom.

Thymus, occurred also in autumn; in this period, they showed great overlap also according to C_{hi}; on the basis of R_{hi} the overlap was great in the species pair *Festuca-Thymus*. The minimal overlap remained also in autumn in the species pair *Fumana-Medicago*, according to the indices; the species pair *Medicago-Cynodon* is also of low overlap, according to C_{hi} and d.
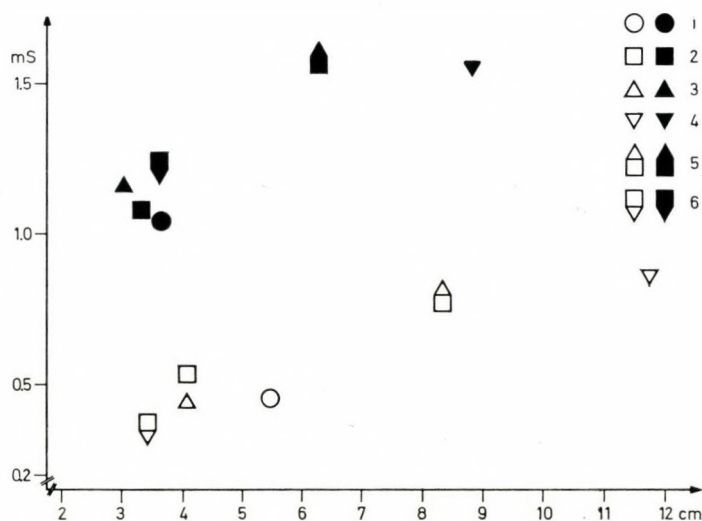
Fig. 2. Position of niche centres on root depth (cm) and soil moisture content (mS) axes in summer and fall. 1: *Festuca*, 2: *Medicago*, 3: *Thymus*, 4: *Fumana*, 5: *Euphorbia*, 6: *Carex*. Empty marks: summer, full marks: fall

It can not be detected correlation in the two sampling times neither between the species effect ranks (cf. Table 32) nor between the community effect ranks. *Fumana* appears to have both in summer and in autumn about identical species and community effects. In summer, the species effect was maximal in *Equisetum;* in autumn this species showed one of the very low values. In both summer and autumn, in the case of *Fumana*, the species and the community effects were minimal. In *Cynodon* and *Thymus*, high species effect and low community effect appeared in autumn. The community effect was strong in both periods in *Festuca*.

According to *D*-analysis (Table 33, Fig. 2), the distance between the summer and the autumn niche centres of all the species is significant. The distance between the two centres (summer and autumn) is the shortest in *Medicago*.

Summary

Considering the seasonal dynamics of niche breadth, the various species behave differently. On the soil moisture content gradient, for example, the most constant is *Festuca vaginata*, with a niche broadest both in summer and autumn. *Centaurea* is an example of seasonal lability: by the autumn it becomes a soil moisture "generalist". An example of specialization for autumn is *Euphorbia*. In any case, the fluctuation of summer and autumn is not general; *Equisetum*, *Cynodon* and *Fumana* remain "specialists".

On the root depth axis indicating the utilization of space, the seasonal fluctuation is much greater than on the soil moisture content axis. The cause of this is not completely clear. Root depth (or more exactly: the depth of the maximum root mass) depends on the different life cycles of the species; this, however, does not imply a change in the variability measures (measure categories). Niche breadth here is seasonally mostly constant in the case of *Festuca* and *Carex*.

It appears that in summer the species which is of great breadth on the soil moisture content axis has a broad niche also on the root depth axis. This refers also to the other extreme case. In summer, the two-dimensional distribution of the frequency values (combined categories) expresses this correlation in rank (the breadth order according to the combined categories shows a good agreement with these of one dimension). In autumn the two-dimensional breadth sequence is not similar to that formed according to either soil moisture content or root depth. Anyhow, it appears from the data that the interaction of the two factors is different from that in summer.

According to the behaviour recorded in the two-dimensional niche space, the niche volume of *Thymus* is seasonally the most sensitive, and again that of *Carex stenophylla* is mostly constant. The volume of *Euphorbia seguieriana*

is besides that of *Festuca vaginata* which predominates in the community, the greatest both in summer and autumn. This obviously suggests that these two species, in relation to these two factors, can "find a home" (form a home) anywhere in this community. On the other hand, independently of the season, *Equisetum ramosissimum* and *Cynodon dactylon* are of narrow volume, presumably owing to different causes: this ecological specialization in *Equisetum* can probably be traced back to physiological reasons, and again in the case of *Cynodon* it seems a tenable hypothesis (to be checked) that in the assignment of the realized niche of this species, which established itself secondarily here, the competitive effect (narrowing) of the original grassland is also considerable.

The question of the kind of correlation existing between niche breadth and overlap automatically arises. On the soil moisture content axis the summer results show that in the case of a species with broad niche the average overlap (the average formed in relation to the other 8 species) is also great, while species which have become more specialized overlap only to a smaller extent with the others. In autumn, however, the situation is quite different on this same axis. *Festuca* which is of great breadth (first in the order) is the last when considering the average overlap; the order of the other 8 species is very different, according to these two viewpoints. It cannot be left out of consideration that before the autumn measurements there were abundant rains: the water supply of the soil was better than in summer. In the case of an abruptly formed excess, the equilibrium between supply and use obviously does not develop; this certainly influences the values and relations of niche breadths and overlaps. There is no doubt that the copious water supply mentioned above makes the values equalized in autumn. Thus, for example, while in summer the niche breadth of H_i varied between 0.43 and 0.92, in autumn it varied only between 0.55 and 0.82. The average R_{hi} overlap values of the 9 species in summer vary between 0.54 and 0.84; this range narrows in autumn down to 0.74—0.84 m the good water supply favours the formation of high overlap values. From the comparison between the summer and autumn data it is evident that here we are not dealing with a general increase in actual competition. The situation seems rather the opposite: in the case of a poorer water supply, the signs of separation become outlined.

Concerning the average overlap values of the species, in the two-dimensional niche space, all indices resulted in lower values than separately on the individual axes. Obviously, the inclusion of any further axes would increasingly reduce the overlaps. Thus the adding of further factors, the forming of combinations, etc. creates the possibility of more complete analyses of fundamental questions related to the ecological separation of species sets.

The general overlap tendencies are well evaluable in the two-dimensional space. Accordingly, the overlap of *Festuca* (on an average with all the others)

is great both in summer and autumn (the above contradiction is eliminated in two dimensions; cf. autumn overlap on the soil moisture content axis). The general overlap of *Fumana* is the smallest. The average overlap of *Fumana* and *Cynodon* is not influenced by seasonal changes; that of *Euphorbia* on the other hand is considerably influenced; in this the new position occupied by as *Euphorbia* in autumn in the two-dimensional space may also interplay, indicated by the result of *D*-analysis.

The examination of the community matrix suggests that the community effect both in summer and autumn is the greatest on the very *Festuca vaginata* which predominates in the community, while the effect of this species on the community (through the two factors, or more exactly, through their combinations) is only of medium degree. The strongest species effect both in summer and autumn belongs to the adventitious *Cynodon*. In any case, this reciprocal effect may be subordinated to a strong seasonal fluctuation in most of the species. The ecological isolation of *Fumana* is very remarkable: it has no effect on the community, neither has the community on it.

According to the result of *D*-analysis, the niche centre of the species becomes significantly removed by the autumn, in comparison with that of the summer.

It cannot be left unsaid that the adequate interpretation of the numerical results obtained on the basis of the community matrix still awaits its turn. It is hardly possible to obtain one without suitably planned and accomplished series of experiments.

*

Literature was given in Part One of this paper.

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COMPARATIVE ANALYSIS OF GREEN AND SPONTANEOUS ALBINO MUTANT LINES OF NICOTIANA SYLVESTRIS SPEG. ET COMES

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Cytological and some functional peculiarities of a spontaneous albino mutant appeared in 1974 in a haploid plant of *Nicotiana sylvestris* Speg. et Comes and maintained without any changes were determined and compared with the original green plants. It was established that albino plants had significantly high stability of chromosome numbers. The majority of the cells remained permanently haploid in the same conditions as green plants grown. The mutant is chlorophyll deficient and CO_2 fixation is missing from it. In malate dehydrogenase, peroxidase and esterase izoenzyme patterns of green and albino plants specific differences were detected.

Albino and chlorophyll deficient mutants are effectively used, as markers, in classical plant genetics and in cell fusion experiments. Androgenic haploid plants produced by anther cultures have provided good material for the isolation of mutants. It was CARLSON (1970) who first isolated auxotroph mutants from cell cultures of haploid *N. tabacum*. The application of haploid callus and cell suspension cultures for mutant isolation requires caution since diploidization of the haploid cells occurs. Thus, the plants regenerated from these cultures are not purely haploids. Reliable results can only be expected by a continuous control of chromosome number of the regenerated plants.

From haploid callus culture of Petunia hybrida streptomycin resistant cell lines have been isolated by BINDING et al. (1970, 1972). Two of the isolated lines proved to be auxotrophs for auxin. During maintenance of the tissue cultures the streptomycin resistance decreased and they could not regenerate resistant plants.

In the genus *Solanum* the effect of ploidy level on isoenzyme composition of soluble proteins have been studied by DESBOROUGH and PELEGUIN (1967). Comparison of the haploid wild species, interspecific hybrids and tetraploid plants suggests no relationships between number of esterase isoenzyme bands and ploidy level. Peroxidase and esterase isoenzymes of *Nicotiana* species and of their hybrids were studied by SMITH et al. (1970). In species of a taxonomic section the same isoenzyme patterns are found while peroxidases and esterases varied in species of the different sections.

On purpose to verify the origin of *Nicotiana tabacum* peroxidase, esterase, malate dehydrogenase and other isoenzymes of some 60 *Nicotiana* species were

analyzed by SHEEN (1970, 1971). Isoenzyme patterns of *N. sylvestris* and *N. tomentosiformis* were similar to that of *N. tabacum*.

Lethal albino mutants of *Nicotiana tabacum* have been maintained in vitro by adding phytohormones (SHAEFFER and MENSER, 1975). Cytological and biochemical basis as well as characteristics of the mutation have not yet been reported. According to the authors there is significant difference between the green plants and the albino mutants in growth rate.

Since these albino mutant types can be maintained in tissue cultures, thus, they can use marker in different genetical investigations.

Haploid plants of both *Nicotiana sylvestris* Speg. et Comes and *Nicotiana tabacum* cv. Petit Havanna were also produced by MALIGA and SZILÁGYI (1973) using the anther culture method of NITSCH and NITSCH (1969). On an artificial culture medium the sterile haploids could be maintained by serial transplantation of leaf primordia. In these cultures of haploid plants kept in the light shoot parts of white color have appeared in October, 1974. The white plant were cultured separately from the green ones. This white phenotype of the plants was unchanged during the cultivation.

Cytological and biochemical characterization of the mutant phenotype appearing spontaneously were the aim of the present work.

Material and method

Haploid green plants (abbreviated SH) and mutants (abbreviated SHM) of *Nicotiana sylvestris* Speg. et Comes were grown under sterile conditions in 100 ml Erlenmeyer flasks containing a modified culture medium (KOVÁCS, 1971). The cultures were transferred to fresh media in every 3–4 weeks. The cultures were held in a climatic chamber "Mytron" at 24–26 °C in continuous light.

Ploidy of the plants was checked by counting of chromosomes in mitoses. Since albino mutants could not develop roots for this reason young leaves were used for cytological analysis. The young leaves were pretreated with 0.05% colchicine solution for 2.5 hours and the mitoses of acetocarmine stained leaflets were studied by light microscope (SZILÁGYI, 1975). An NFpK 2 microscope with an MF Zeiss camera was used to make microphotographs (magnification was ×1000).

It is completely clear that mutation directly or indirectly affected chloroplasts. Effect of mutation was characterized by measuring the capacity of CO_2 assimilation and of chlorophyll content in leaves indicating the function of chloroplasts.

Study of isoenzymes and of electrophoretic separation of leaf soluble proteins provides data that are in connection with the function of deficient chloroplasts and with requirements making maintaince of albino mutants possible.

Chlorophyll content of leaves was measured by spectrophotometrically in ethyl ether solutions after the extraction with aceton. In vivo *assimilation of* CO_2 was characterized by the radioactivity of leaf discs incubated in atmosphere containing $^{14}CO_2$. In vitro assimilation was measured by ^{14}C incorporation into organic bound in a solution containing leaf extract in the presence of ribulose-1.5-diphosphate as substrate (BJÖRKMAN, 1968, NAGY et al., 1973).

Leaf extract of plants was submitted to polyacrylamide gel electrophoresis. The malate dehydrogenases were separated on 6 per cent gel, the electrode buffer was tris-glycine at pH 8.3. A current not exceeding 2 milliamps per tube was applied. Isoenzyme bands were stained in a solution containing sodium malate, as substrate, NAD as coenzyme and PMS, NBT indicator dyes at pH 8.0. In this system the RuDP carboxylase band was red and the malate dehydrogenases developed violet colour (MAUER, 1971).

Peroxidases were separated in 7.5 per cent gel under the same conditions described before. The staining solution consisted of o-dianisidine dissolved in ethanol and H_2O_2 as substrate in acetate buffer at pH 4.7 (SMITH et al., 1970).

Isoelectric focusing of *esterases* was carried out in the presence of ampholine pH 3—9 at 300 volts. Time of separation was 4 hours. The bands were developed in a reaction mixture containing α-naphthylacetic acid as a substrate and fast blue RR indicator dye in phosphate buffer at pH 6.2.

Proteins were stained with 0.5 per cent of Coomassie blue in 20 per cent trichloroacetic acid solution. The experiments were repeated three times using 3—4 parallels in each. In the illustration one of the gels is shown.

Experimental results

The spontaneous albino mutants derived from green leaf cultures of haploid *N. sylvestris* plants are propagated by serial passages. We have been maintaining these albino mutants isolated in 1974 for 2 years. The mutants maintained are stable and there are no changes in their phenotype. A green and an albino mutant culture are shown in Fig. 1. Young leaves of the albino mutants having pale green colour become white in continuous light.

The chromosome number of the plants studied was also determined. It was shown that ploidy level in the albino mutants was more stable then in the green plants (Table 1). Figures 2 and 3 show haploid and diploid cells.

Data of the table clearly indicate an increased diploidization of green plants. Moreover 7 tetraploid cells were also found among them. On the other hand, cells of the albino leaves kept the original haploid level by far the greatest number and only a small proportion of plants was diploid.

On the basis of the facts above mentioned it is evident that there are variations in ploidy level of both green and albino plants. For this reason in the present comparative experiments only haploid samples of both green and albino plants are used. Since the pigment deficiency suggests some disturbances of chloroplast function of albino mutants, first, data connected with these observations are presented. Chlorophyll content of young leaves of green and albino plants were determined. Means of chlorophyll content and the ratios of chlorophyll a to b are shown in Table 2.

In mutant leaves the amount of chlorophyll is only 10 per cent of normal green plants. In continuous light the mutants become completely white.

Table 1

Chromosome number of green and albino Nicotiana sylvestris Speg. et Comes plants

Plant material	Observed cell number			
	n = 12	2n = 24	4n = 48	
SH	20	247	7	
SHM	403	84	—	
Total	423	331	7	761

Table 2

Chlorophyll content and ratio of chlorophyll a to b in green and albino Nicotiana sylvestris Speg. et Comes plants

Plant material	Total chlorophyll nmole/g fresh weight	Chlorophyll a/b
SH	293	2.5
SHM	25	2.8

There is no significant difference between green and albino plants concerning chlorophyll a/chlorophyll b ratio.

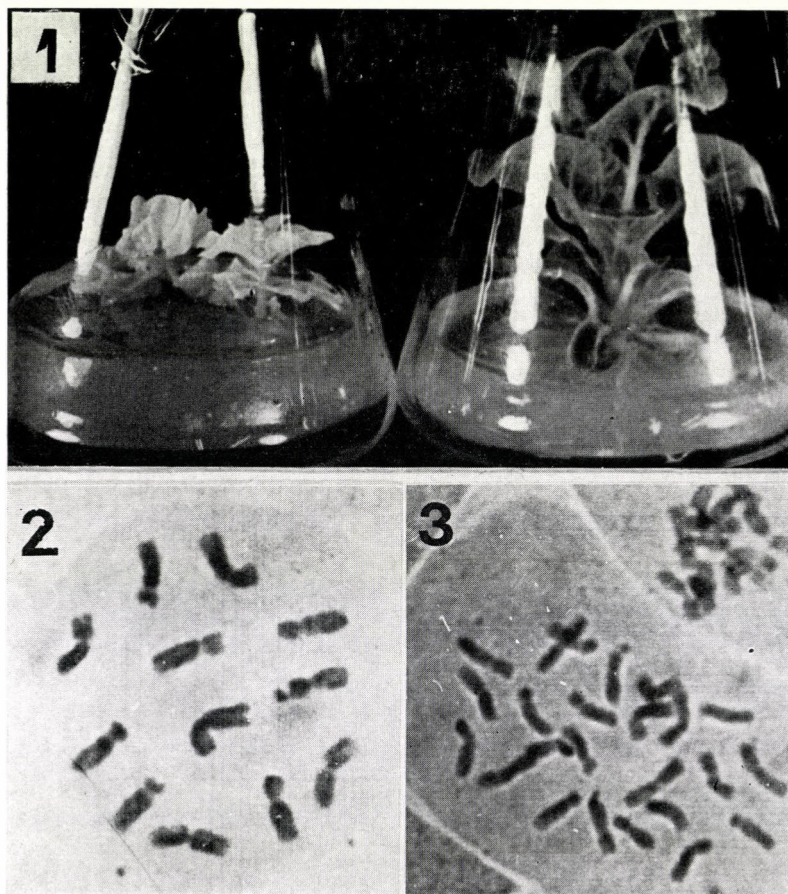
Table 3 illustrates the photosynthetic CO_2 fixation and RuDP carboxylase activity. Determinations were performed with young leaves.

Figs 1—3. 1: Cultures of green — SH (right) and albino — SHM (left) *Nicotiana sylvestris* Speg. et Comes. 2: A haploid cell of *Nicotiana sylvestris* Speg. et Comes (×1000). 3: A diploid cell of *Nicotiana sylvestris* Speg. et Comes (×1000)

Table 3

Photosynthetic CO_2 assimilation in leaves of Nicotiana sylvestris Speg. et Comes green and albino plants

Plant material	RuDP carboxylase nmole CO_2/g fresh weight/hour	In vivo $^{14}CO_2$ assimilation 10^5 cpm/cm²/hour
SH	980	28.5
SHM	290	....

According to the data of the table the enzyme isolated from young leaves of albino mutants can work under optimum conditions. In vivo this working capacity of CO_2 assimilation cannot be realized.

Results of electrophoretic experiments performed on leaves of haploid plants grown conditions have described before are illustrated in Figs 4—6. Nine malate dehydrogenase isoenzymes can be separated. In the reaction mixture described the tenth band of 0.18 Rp value gives a red colour corresponding to the enzyme protein of the RuDP carboxylase. In accordance with the above mentioned data this enzyme is inactive in the mutant plants. Protein staining of this band of the mutant is more weaker than that of the green plant. One isoenzyme of 0.26 Rp value of malate dehydrogenases is absent from the mutant which confirms the protein patterns (Fig. 4).

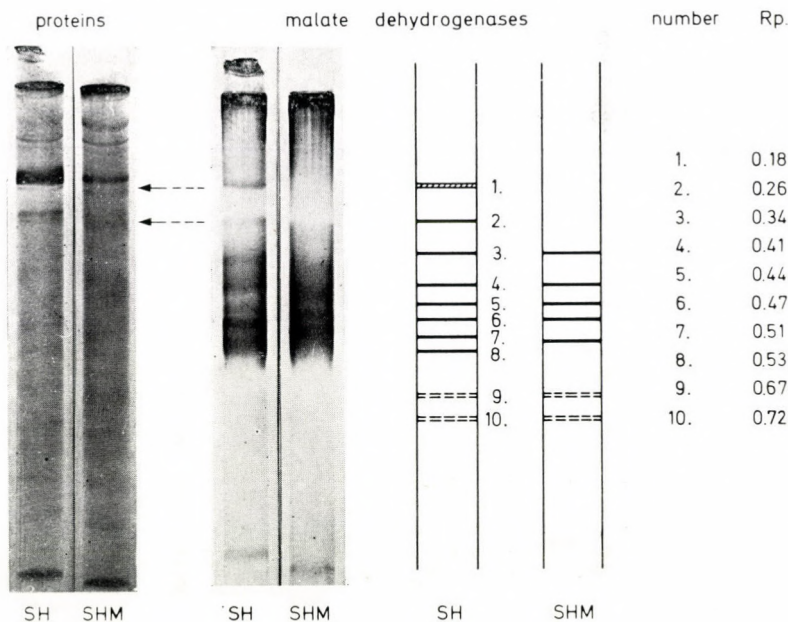



Fig. 4. Protein (left) and malate dehydrogenase isoenzyme (right) patterns of leaf extracts of green — SH and albino — SHM *Nicotiana sylvestris* Speg. et Comes

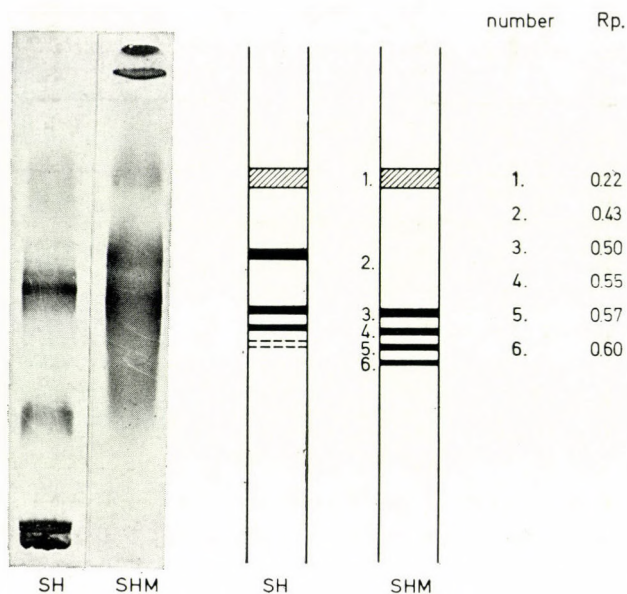



Fig. 5. Peroxidase isoenzyme patterns of leaf extracts of green — SH and albino — SHM *Nicotiana sylvestris* Speg. et Comes

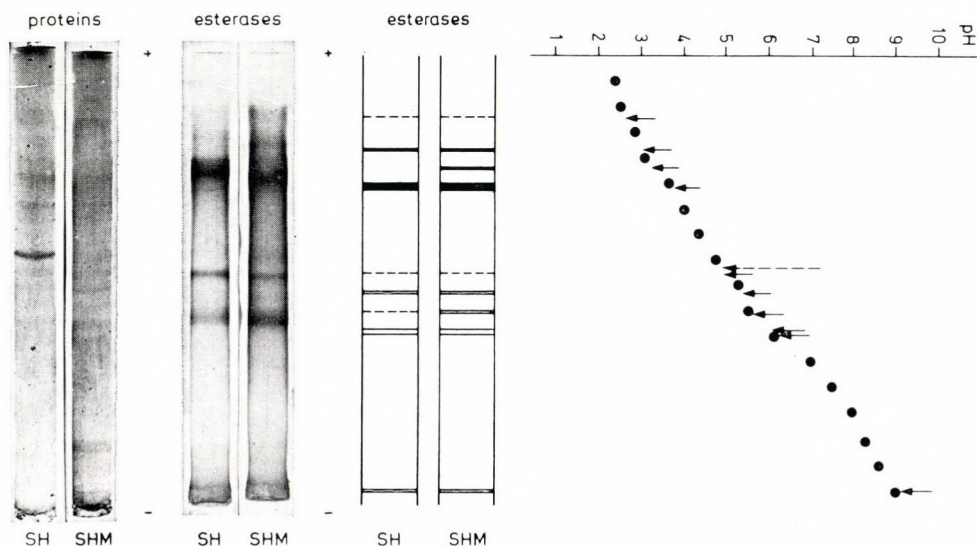



Fig. 6. Separation of proteins (left) and esterase isoenzymes (right) by isoelectric focusing in leaf extract of green — SH and albino — SHM *Nicotiana sylvestris* Speg. et Comes

Six peroxidase isoenzymes can be visualized by o-dianisidine and H_2O_2 system. The mutant leaves have no band at Rp 0.43.

A strongly stayning band of Rp 0.43 is absent from the mutant leaves and at the same time the bands at Rp 0.22 and 0.60 have higher colour intensity (Fig. 5).

Ten isoenzyme bands were identified by isoelectric focusing. Differences could only be detected in acidic pH range. In the mutant extract an intensive band was found at pH 3.4. This band was missing from extract of the green leaves. The band at pH 5.7 was present in the mutants only. In leaf extracts of the green plants an intensive band with high amount of protein having isoelectric point at pH 5.0 was detected by staining the proteins. This band was not present in the albino mutants (Fig. 6).

Discussion

Spontaneous and induced chlorophyll deficient mutants are usually used in genetical experiments. The different varieties of them are well known in *Angiospermae* plants (KIRK, 1972, GOUGH, 1972, TRAVIS et al., 1975, VAGERA et al., 1976).

The chlorophyll deficient and chloroplast defective characters of plants can be brought about by genetic change either in genome or in plastome. Interaction between an organellum and cell is complicated since protoplasm of higher plants is extraordinarily complex and differentiated. Because of complex influences the primary locality of a genetic change cannot be detected by simple experimental approaches. In the present period of the authors' experiments carried out on tobacco albino mutants data were obtained for deep-rooted analysis of phenotype rather than for probable locality of the genetic block. Mutagene treatment was not applied for this reason, the mutation studied could be considered spontaneous. Due to pigment deficiency the albino plants are lethal. They have no photosynthesis and ability to form roots. Growth intensity of the mutant is lower than that of the green type. This characteristic is similar to that of the albino mutants of *Nicotiana tabacum* isolated by SCHAEFFER and MENSER (1975).

The obligate requirement for indoleacetic acid of the mutant studied agrees with their data, too. During our extensive investigation abnormalities in chromosome morphology, breakages and unusual mitoses could not be detected by cytological analysis. Stability of chromosome number in the albino plants is remarkable. The diploidization observed in the normal type is rather in agreement with the literary data (SZILÁGYI, 1975). To stabilize the haploid level of cell cultures a para-fluorophenylalanine treatment is recommended by GUPTA and CARLSON (1972). Stability of chromosome number

of the albino mutant isolated in our laboratory may be in connection with the reduced level of growth. During growth and development of plants it is well known that the change of ploidy level occurs and only the developed stage is characterized by stable chromosome counts. Since the albino types have a reduced growth intensity, therefore the instability characterizing an intensive growth period does not occur.

Deficiency of chloroplast functions is consequent upon the low chlorophyll content of the albino leaves and upon the disappearance of their pale green colour in light. In albino leaves inactivity of RuDP carboxylase enzyme of CO_2 fixation pathway, a characteristic protein of chloroplasts, was proved by the authors' experimental results. Measurable activity in vitro suggested the presence of the enzyme protein in the young pale green leaves, however, it could not function due to the absence of photoreactions in vivo. In the monogenic recessive ζ-carotene mutant of maize (Nagy, 1975) and in white segments of the variegated probably plastom mutant *Tradescantia albiflora* (Gyurján et al., 1976) a similar functional disturbance was found. Reduced amount of the RuDP carboxylase enzyme protein and absence of the activity were proved by the data of electrophoretic observations.

RuDP carboxylase, a key enzyme of photosynthetic CO_2 assimilation is encoded in DNA of both nucleus and chloroplast (Kawashima and Wildman, 1972). Pathways of chlorophyll synthesis are completely coded by the nucleus (Kirk, 1976, Wettstein et al., 1971). Mistake of the genetic code regulating any above mentioned function results in similar phenotypic change. The exact localization of the mutation requires cross-breeding experiments.

Isoenzyme studies of *Nicotiana* species have been extensively used for the analysis of their phylogenetic relationships. All the characteristic izoenzymes of *Nicotiana sylvestris* (Smith, 1970, Sheen, 1971) were found in our experiments, too though there were some differences in the experimental circumstances. Composition of izoenzyme patterns depends on growth conditions, components of media and on stages of ontogenesis. Though the mutation observed is evidently lethal therefore, the maintenance of the albino mutant leaves on nutrient media suggests metabolic pathways producing enough energy for growth in spite of complete deficiency of the photosynthetic CO_2 fixing system.

The differences described between green and albino leaves refer equally to genetic block and different metabolic pathways, too. The characteristic data described can be applied as markers of the mutant in further experiments.

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NUMERICAL EVALUATION OF PHENOTYPIC RELATIONSHIP AMONG HUNGARIAN SPECIES OF GENTIANA

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The authors have attempted to make a numerical evaluation of similarities and dissimilarities in morphological characters of four species of Gentiana [viz. *G. ciliata* (1.), *G. pneumonanthe* (2.), *G. cruciata* (3.), *G. asclepiadea* (4.)] reported from Hungary.

Forty-tree exomorphic characters, selected from different part of the plants, have been tabulated in form of a polytomic key. Out of these, eight well-marked quantitative characters have been tested by variance analysis.

The result of our study reveals that *G. ciliata* shows a very low degree of affinity with the other three species of *Gentiana*. Thus, its exlusion from *Gentiana* appears to be more probable. We, therefore, support FROELICH (1796), LINK (1921), GRISEBACH (1839) and TUTIN and HEYWOOD (1973) in treating this species under *Gentianella*.

Introduction

Gentiana Linn., the type genus of the family *Gentianaceae*, owes its name in honour of GENTIUS, a king of Illyrius (about 500 B. C.) who was supposed to have discovered the medicinal properties of *Gentiana* root (*G. lutea* Linn.) as a remedy for plauge (cf. SEN 1977). This name was proposed by TOURNEFORT (1700) and later published by LINNAEUS in his Species Plantarum (1753). GRIESEBACH (1839) split it into two subgenera — *Gentianella* and *Eugentiana*. KUSNEZOW (1896—1906), in his monographic study of *Eugentiana*, followed GRIESEBACH (l. c.) and enumerated the following distinguishing characteristics:

Gentianella	*Eugentiana*
1. Folds absent between calyx and corolla	1. Folds always present
2. Basal portion of the corolla tube with nectar cells	2. Nectar cells absent at the base of the corolla tube
3. Apical portion of the petals rounded or acute when petals 3 or 5	3. The apical portion of petals always acute with three veins

KUSNEZOW (l. c.) emphasised that presence of the folds between the calyx and corolla was the main character to separate *Eugentiana* from *Gentianella* (Fig. 1). Further, in *Eugentiana* the stamens were fused at the base of

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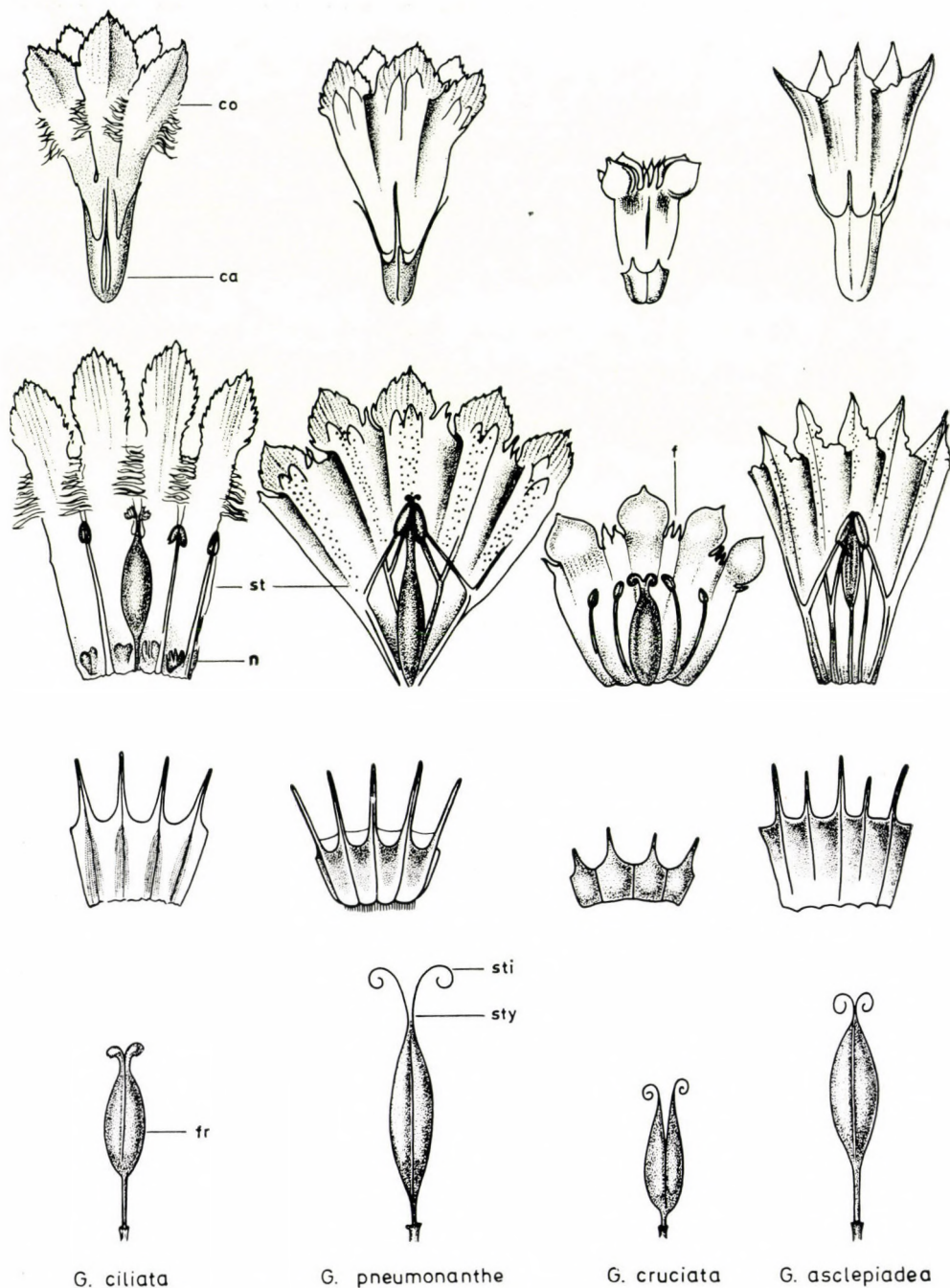


Fig. 1. Reproductive parts of the four *Gentiana* species. Signs: ca = calyx; co = corolla; f = fold; fr = fruit; n = nectar cells; st = stamen; sti = stigma; sty = style

the petals and ovaries and fruits were stalked. On the other hand, the ovaries and fruits of *Gentianella* were without stalk except the section *Crossopetalum*. The family *Gentianaceae* has generally been divided into two families (GILG 1895) — the *Gentianoideae* and *Menyanthoideae*, which can be distinguished by the following characters:

Gentianoideae	*Menyanthoideae*
1. Terrestrial plant	1. Marshy or aquatic plant
2. Leaves opposite	2. Leaves alternate
3. Corolla involute or imbricate	3. Corolla induplicate-valvate

DON (1838), BRITTON (1897) and WETTSTEIN (1935) are, however, of the opinion that these two taxa should be elevated to the rank of independent families, a view supported by the morphological and anatomical findings of LINDSEY (1938).

In the present investigation, the authors have attempted to make a numerical evaluation of morphological characteristics of the Hungarian species of *Gentiana* with a view to finding out the degree of their mutual relationship i.e. similarites and dissimilarites between them, and to facilitate their easy identification. We have been influenced by the views of SOKAL and SNEATH (1963), GIVEN (1969), MCNEILL, PARKER and HEYWOOD (1969) and HORÁNSZKY (1969). It is interesting to quote SOKAL and SNEATH (l. c.) that "The degree of overall similarities of two or more organisms, represented by numerical values will considerably help the traditional taxonomists" and that the numerical taxonomy is "the numerical evaluation of the affinity or similarity between taxonomic unit and the ordering of these units into taxa on the basis of their affinites". DUTTA (1975) has also given a similar emphasis to numerical evaluation of characters, that "the degree of overall similarity of two or more organisms, represented by numerical values, will considerably help the traditional taxonomists who aim at creating a classification, and the modern biosystematists who are trying to gain an understanding for the reasons leading to the similarities and dissimilarities between the taxa.

From Hungary, six species of *Gentiana* were originally reported, viz. *G. ciliata* L., *G. asclepiadea* L., *G. pneumonanthe* L., *G. cruciata* L., *G. livonica* (Ledeb.) Eschh., *G. austriaca* A. and J. Kern. (SOÓ-JÁVORKA, 1951). SOÓ (1966) following KUSNEZOW (l. c.) has treated the four species under the genus *Gentiana* (*G. ciliata* L., *G. pneumonanthe* L., *G. cruciata* L., *G. asclepiadea* L.) and has shifted other two species under the genus *Gentianella* (*G. livonica* (Lebed. Soó, *G. austriaca* A. et J. Kern.) Dost. 1954 (cf. Soó 1966), TUTIN and HEYWOOD in Flora Europaea (1972) have treated *G. ciliata* L. under the genus *Gentianella*. They have based their opinion on the data supplied by H. MERXMÜLLER. RECHINGER (1966), however, did not treat *G. ciliata* L. under *Gentianella*. The present study has been carried out on four species, namely *G. ciliata* L., *G. pneumonanthe* L., *G. cruciata* L., *G. asclepiadea* L., following SOÓ (1966),

with a view to ascertaining the systematic position of *G. ciliata* L. on the basis of numerical evaluation of morphological characteristics and to illustrate the relationship among the species.

Material and methods

All our observations are based only on the dried herbarium specimens of Herbarium Budapest (H. B.). Forty-three exomorphic characters were selected from a herbarium specimen of each species and studied critically. This process was repeated fifteen times on fifteen different specimens of each species in developmental stadium and phenophases like 23, 31, 32 and 42 (Szujkó-Lacza and Fekete, 1973). Numbers 24, 31, 32 and 42 here represent the different developmental stadium of the same plant, viz. leaf growth termination, shoot with flower bud, beginning of flowering and start of denudation of shoot and leaves, respectively. The repetition of the same developmental stadium was found to be high because we could study only the herbarium specimens collected by different collectors at different times from different localities. The exomorphic characters studied have been enumerated in the Table 1 in form of a polytomic key, giving different numbers to different characters. The similarities and dissimilarities of characters have been expressed in form of two states in column 5 following Sokal and Sneath (1963). The characters which show similarities and dissimilarities among the species have been coded by the expression 1 and 0, similar and dissimilar, respectively, while those differing in every species by the expression 2. In some cases the quantitative characters are quite variable in the same species. No coding has been done in such cases and the values have been taken as such.

Further, the qualitative character differences like 20 have not been considered numerically. The total and percentage of similarities of different species combinations have been tabulated in Table 2. Table 3 shows the total and percentage of dissimilar characters in each species.

Out of forty-three exomorphic characters, eight marked quantitative characters have been selected for variance analysis following Sváb (1967). We selected the leaves for measurement from the middle portion of the plants where all the characters appear to be more prominent (Zalensky 1904; more exactly Szujkó-Lacza 1974). In case of length we measured from petiole to apex and in breadth widest portion in the middle. The length—width ratios are given in Table 1 after Hickey (1972).

Results and discussion

At first, we represent the result in the polytomic key of the four *Gentiana* species and the basic data for discussion.

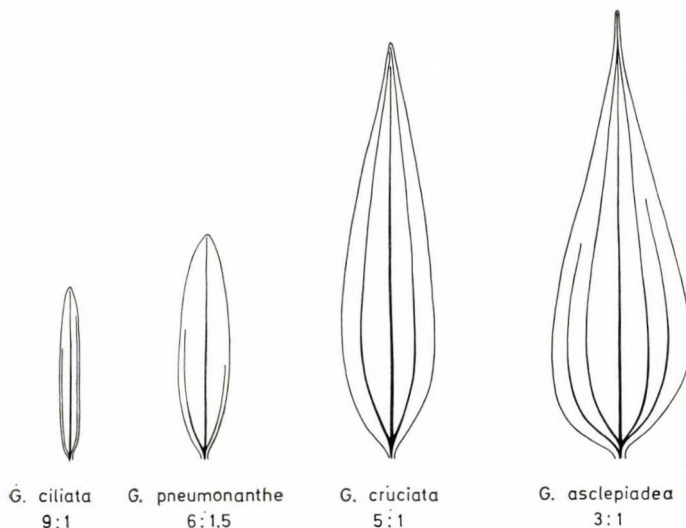



Fig. 2. The exomorphic character and length/width ratio of the leaves of *Gentianella ciliata*, *Gentiana pneumonanthe*, *G. cruciata*, *G. asclepiadea*

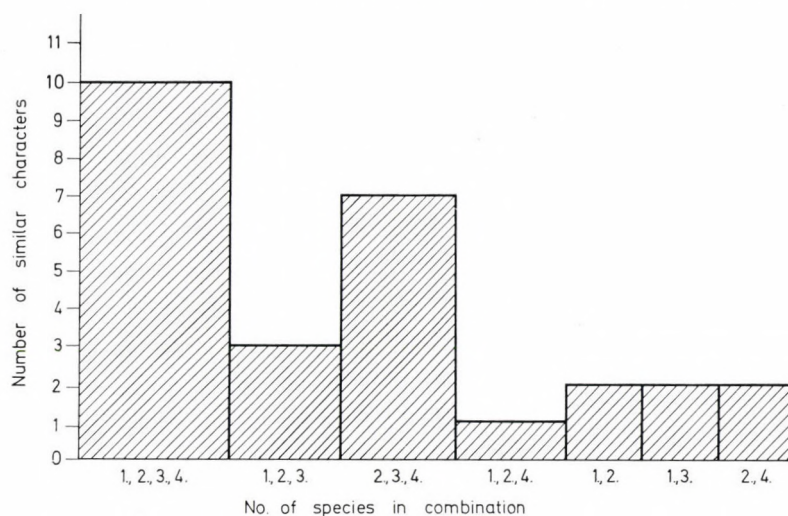



Fig. 3. Similar morphological characters in different combination of species

Number of dissimilar characters

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23

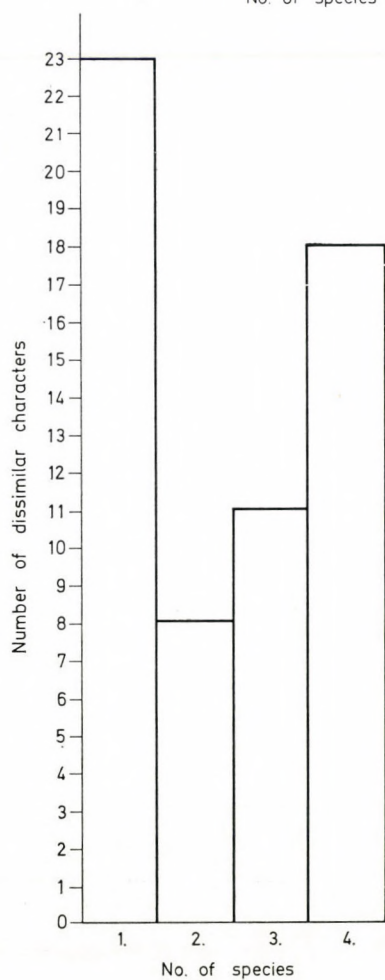
1. 2. 3. 4.

No. of species

Fig. 4. Number of dissimilar exomorphic and quantitative characters for each species

Table 1

Polytomic key for four Gentiana species

No. of character	Characters	1. G. ciliata	2. G. pneumonanthe	3. G. cruciata	4. G. asclepiadea	Sign of differences			
1	Primary root	1	0	0	0	1	0	0	0
2	Rhizome	0	1	1	1	0	1	1	1
3	Stem divided by internodes	1	1	1	1	1	1	1	1
4	Number of stem	3—13, sometime unbranched	6—9	3—7	3—5	3—13	6—9	3—7	3—5
5	Height of stem	measured	measured	measured	measured				
6	Length of the branches	measured	measured	measured	measured				
7	Shoot erect or prostrate	1	1	1	1	1	1	1	1
8	Shape of stem lineolate or cylindrical	0	0	1	0	0	0	1	0
9	Hairy or naked	1	0	0	0	1	0	0	0
10	Phyllotaxy opposite cuneate or opposite decussate	0	0	0	1	0	0	0	1
11	Sessile or petiolate	0	0	0	1	0	0	0	1
12	Symmetrical or asymmetrical	1	1	1	1	1	1	1	1
13	Shape of leaves	narrow lanceolate—lanceolate	ovate-narrow lanceolate—lanceolate	ovate-lanceolate or oblong	wide lanceolate—lanceolate	2	2	2	2
14	Length—width ratio	9 : 1	6 : 1.5	5 : 1	3 : 1	2	2	2	2
15	Leaves hairy or naked	1	0	0	0	1	0	0	0
16	Leaf apex acute of acuminate	1	1	1	0	1	1	1	0
17	Leaf base truncate or obtuse	1	1	0	0	1	1	0	0
18	Margine of leaves entire or not	1	1	1	1	1	1	1	1
19	Number of veins with midrib	3	1—3—5	3—5	5	3	1—3—5	3—5	5
20	Inflorescences terminal cymes or terminal + axillary both	1	0	0	0	1	0	0	0
21	No. of flowers originated in each internode	1	1—3 (6)	3—10	1—3	1	1—3 (6)	3—10	1—3
22	Flowers pedicillate or sessile	1	1	0	0	1	1	0	0

Table 1 (cont.)

Number and name of species									
No. of character	Characters	1. G. ciliata	2. G. pneumunanthe	3. G. cruciata	4. G. asclepiadea	Sign of differences			
23	Length of pedicels	1—1.5 cm	0.3—0.4 cm	sessile	sessile or sub-sessile				
24	Length of the calyx tube	measured	measured	measured	measured				
25	Number of sepals	4	5	4	5	4	5	4	5
26	Sepals linear or curvilinear	curvilinear	narrowlinear	linear (two short and two long)	linear and unequal	2	2	2	2
27	Sepals glabrous or pubescent	1	1	1	1	1	1	1	1
28	Shape of corolla funnel or tubular	1	0	0	0	1	0	0	0
29	Length of corolla tube	measured	measured	measured	measured				
30	Folds between petals present or absent	0	1	1	1	0	1	1	1
31	Petals pubescent or glabrous	1	0	0	0	1	0	0	0
32	Colour of flower	blue	blue with greenish lines	blue	blue with reddish purple spots in side	1	2	1	1
33	Number of stamens	4	5	4	5	4	5	4	5
34	Epipetalous or free	1	1	1	1	1	1	1	1
35	Filaments flattened or linear	1	1	1	1	1	1	1	1
36	Length of the filaments	measured	measured	measured	measured				
37	Anthera oblong or other types	1	1	1	1	1	1	1	1
38	Length of gynoecium	measured	measured	measured	measured				
39	Style short or absent	measured	measured	measured	measured				
40	Stigma bilobed or other types	1	1	1	1	1	1	1	1
41	Fruit stalked or sessile	1	1	0	1	1	1	0	1
42	Shape of capsule oblong or other types	1	1	1	1	1	1	1	1
43	Shape of seeds	oblong with narrow and acute apex	ovate narrow obtuse apex and not winged	ovate with narrow apex and not winged	globose with obtuse apex and winged				

Table 2

Similar morphological character in different combination of species (number of characters like Table 1)

Number of species in combination	Character number	Total number of similar characters in each combination	%
1, 2, 3, 4	3, 7, 12, 18, 27, 34, 35, 37, 40, 41	10	16.9
1, 2, 3	10, 11, 16	3	5.0
2, 3, 4	1, 2, 9, 15, 20, 30, 31	7	11.8
1, 2, 4	41	1	1.6
1, 2	17, 22	2	3.3
1, 3	25, 33	2	3.3
2, 4	25, 33	2	3.3

Table 3

Dissimilar exomorphic characters for each species

Species number	Character numbers (like Table 1)	Total	%
1	1, 2, 9, 13, 14, 15, 20, 21, 26, 28, 30, 31, 43	13	22.0
2	13, 14, 26, 28, 32, 43	6	10.1
3	4, 8, 13, 14, 26, 43	6	10.1
4	10, 11, 13, 14, 16, 26, 43	7	11.8

Table 4

Number of identical exomorphic characters in different combination of species

Species number in combination	Total number of common or similar characters
1, 2	16
1, 3	15
1, 4	11
2, 3	20
2, 4	19
3, 4	17
1, 2, 3	13
1, 2, 4	11
1, 3, 4	10
2, 3, 4	17
1, 2, 3, 4	10

One of the best character among the four species the length/width ratio of the leaves (Fig. 2) on the middle position of steam.

According to Fig. 3 and 4 the larger part of the similar characters originated from the 2nd, 3d and 4th species and the 1st gives the highest number of dissimilarities.

According to Table 2, 3 and 4, characters common among four species: 3, 7, 12, 18, 27, 35, 37, 40, 42. The number of similar characters is very high. So they indicate not only the similarities among the four species but probably also some generic characters.

Characters common among *G. pneumonanthe*, *G. cruciata* and *G. asclepiadea:* 1, 2, 9, 15, 20, 21, 28, 30, 31.

Character common among *G. ciliata*, *G. cruciata*, *G. asclepiadea:* 32

Character common among *G. ciliata*, *G. pneumonanthe*, *G. asclepiadea:* 42

Characters common among *G. ciliata*, *G. pneumonanthe*, *G. cruciata:* 10, 11, 16

Individual characteristics of *G. ciliata:* 1, 2, 15, 20, 21, 28, 30, 31

Characteristic features of *G. cruciata:* 4, 8

Individual characteristics of *G. asclepiadea* 10, 11, 16

Character number 13 and 14 are appropriate for the separation of these four species when taken together, whereas character number 26 and 42 are suitable for differentiation of these species individually.

From Table 2 and 4 we can conclude that many morphological characters of species 2, 3, 4 are similar and therefore they come very near to each other. *G. ciliata* differs from other three species in 13 characters.

Tables 16, 19 show maximum S.Ds. in character number 29 and 36. The next in descending order are the character numbers 6 and 24. The next comes character number 5. The character number 38 shows the minimum S.Ds., while no S.Ds. in found in 4 and 23.

Table 5

Heigth of stem in mm

Specimens / No. of species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
1	180	174	90	160	142	95	100	113	130	200	152	270	300	295	160	171
2	200	260	100	600	580	320	420	452	284	601	550	480	380	250	212	379
3	340	140	130	345	217	295	180	520	255	302	235	240	210	190	175	252
4	625	440	580	730	700	750	615	600	623	400	454	550	520	480	701	585

Table 6

Analysis of variance of the data

Source of variability	SQ	FG	MQ	
Treatment = species	1 464 502	3	488 167	
Residual	609 099	56	10 877	F = 44 806
Total	2 073 601	59		

Table 7

Averages (in the diagonal), their differences (in the right upper half of the matrix), levels of significance according to species

Species	1	2	3	4
1	171	208	81	414
2		379	127	206
3			252	333
4	*		*	585

Significance levels: * P = 53; ** P = 1%; *** P = 0.1%

Table 8

Length of the branches in mm

Specimens / No. of species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
1	62	31	20	25	28	52	130	100	12	60	32	18	92	110	80	56.8
2	200	210	150	102	98	450	552	600	270	292	150	100	510	280	92	270.4
3	232	520	150	85	305	420	520	302	210	190	340	255	175	140	180	268.3
4	600	440	730	580	700	613	600	400	454	550	750	730	455	520	480	573.5

Table 9

Analysis of variance of the data

Source of variability	SQ	FG	MQ	
Treatment = species	2 033 582	3	677 860	
Residual	855 207	56	15 272	
Total	2 888 789	59		F = 44.3

Table 10

Averages (in the diagonal), their differences (in the right upper side of matrix), levels of significance according to species

Species	1	2	3	4
1	56.8	213.6	30	516.7
2		270.4	243.6	303.1
3			26.8	546.7
4	*	*	*	573.5

Table 11

Length of the calyx tube in mm

Specimens / No. of species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
1	20	18	25	16	19	20	17	24	21	16	18	20	21	18	26	19.9
2	18	22	17	25	22	28	24	18	21	17	18	20	22	23	24	21.2
3	7	10	6	8	11	7	8	8	7	10	7	11	8	9	7	8.3
4	20	18	22	21	23	21	18	17	19	17	20	22	18	17	22	19.7

Table 12

Analysis of variance of the data

Source of variability	SQ	FG	MQ	
Treatment = species	1648	3	549	
Residual	278	56	5	F = 509
Total	2026	59		

Table 13

Average (in the diagonal), their differences (in the right upper side of matrix), levels of significance according to species

Species	1	2	3	4
1	19.9	1.3	11.6	0.2
2		21.2	12.9	1.5
3	**	**	8.3	11.4
4			**	19.7

Table 14

Length of the corolla tube in mm

Specimens / No. of species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
1	52	48	52	47	50	28	53	48	47	38	51	49	38	48	56	47.0
2	42	46	41	42	38	43	41	42	41	43	42	40	41	42	43	41.8
3	19	25	25	26	24	22	25	23	25	28	28	21	19	25	24	23.8
4	41	42	38	37	42	43	42	38	39	40	41	38	42	40	37	40.0

Table 15

Analysis of variance of the data

Source of variability	SQ	FG	MQ	
Treatment = species	4515	3	1505	
Residual	915	56	5	F = 301
Total	5430	59		

Table 16

Average (in the diagonal), their differences (in the right side of matrix), levels of significance according to species

Species	1	2	3	4
1	47.0	5.2	23.2	7.0
2	*	41.8	18.0	1.8
3	***		23.8	16.2
4	*		*	40.0

Table 17

Length of the filament in mm

Specimens / No. of species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
1	18	17	16	18	16	17	18	17	20	16	17	18	15	16	19	17.0
2	24	27	26	28	24	28	30	25	26	28	25	26	31	27	32	27.1
3	8	9	7	10	11	9	8	8	7	8	10	8	9	7	7	7.4
4	18	17	18	16	18	17	20	18	19	18	17	18	16	20	18	17.8

Table 18

Analysis of variance of the data

Sources of variability	SQ	FG	MQ	
Treatment = species	2638	3	879	
Residual	156	56	3	F = 293
Total	2794	59		

Table 19

Average (in the diagonal), their differences (in the right upper side of matrix), levels of significance according to species

Species	1	2	3	4
1	17	10.1	8.6	0.8
2	**	27.1	18.7	9.3
3	*		8.4	9.4
4	**		**	17.8

Table 20

Length of the gynoecium in mm

Specimens / No. of species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
1	20	24	18	21	20	22	17	21	18	17	21	16	16	18	22	19.4
2	27	34	32	30	28	31	27	31	32	29	28	29	31	29	28	29.7
3	19	15	22	18	23	24	25	19	22	21	23	20	19	20	22	20.6
4	32	31	28	34	28	32	30	31	29	32	31	28	29	31	29	30.4

Table 21

Analysis of variance of the data

Source of variability	SQ	FG	MQ	
Treatment = species	1534	3	511	
Residual	1205	56	22	F = 23.2
Total	2739	59		

Table 22

Average (in the diagonal), their differences (in the right upper side of the matrix), levels of significance according to species

Species	1	2	3	4
1	19.4	10.3	1.2	11.0
2		29.7	9.1	0.7
3			20.6	9.8
4	*			30.4

Table 23

The number of S.Ds. (significant differences) in eight characters at different probability levels according to character number

Character number	$P_{5\%}$	$P_{1\%}$	$P_{0.1\%}$	Σ
4	0	0	0	0
5	2	0	0	2
6	3	0	0	3
23	0	0	0	0
24	0	3	0	3
29	2	1	1	4
36	1	3	0	4
38	1	0	0	1
Σ	9	7	1	$\Sigma\Sigma = 17$

Table 24

Distribution of S.Ds. per quantitative morphological character (a) in each species (b). Symbol: I = sum of row

b \ a	4	5	6	23	24	29	36	38	I
1									0
2						1	1		2
3					2	1	1		4
4		2	3		1	2	2	1	11
Σ	0	2	3	0	3	4	4	1	$\Sigma\Sigma =$ = 17

Table 25

Number of S.Ds. per species pair regardless of the nature of quantitative morphological character

Symbols: I = sum of row; II = number of S.Ds. (number of observations in percentage); III = sum of row and column

b \ b	1	2	3	4	I	II	III
1	0	0	0	0	0	0	10
2	2	0	0	0	2	2.0	4
3	3	1	0	0	4	4.1	9
4	5	1	5	0	11	11.4	11
Σ	10	2	5	0	$\Sigma\Sigma = 17$	17.5	34

Table 26

Number of dissimilar exomorphic and quantitative characters for each species

No. of species	Dissimilar		
	exomorphic characters	quantitative characters	Total
1	13	10	23
2	6	2	8
3	6	5	11
4	7	11	18
Σ	32	28	$\Sigma\Sigma = 60$

The Table 24 shows relative differences in quantitative characters between the species. The gradual increase of S.Ds. from 1st to 4th indicates the distance of dissimilarity between them.

The four species show dissimilarities from each other in eight characters. The total values of S.Ds. is therefore 96. The column II of the Table 25 indicates that the maximum values of S.Ds. is reached in *Gentiana asclepiadea* because this species differs from all other species in eleven characters.

Maximum dissimilarities are found in the 1st species, and the next in descending order is the species number four. On the other hand, the 2nd and 3rd species are very near to each other (Table 26).

Conclusion

Ten characters have been found to be common to all the four species, while seven to species No. 2, 3 and 4 (Table 2). Percentage of similarities indicate that *G. pneumonanthe*, *G. cruciata* and *G. asclepiadea* show a high degree of affinity among each other, whereas *G. ciliata* stands out by its individual characteristics. Character number 13 and 14 are appropriate for the separation of these species when taken together, whereas character number 26 and 42 are suitable for differentiation of these species individually (Table 3).

Of the eight quantitative characters selected for variance analysis, three characters, viz. number 4, 5, and 6 are vegetative and five are reproductive, namely number 23, 24, 29, 39 and 38.

The sum of the significant differences of vegetative characters has been found to be 5, while that of reproductive characters is 12. Maximum significant differences are noticed in character number 29 and 36 (Table 24). The next in descending order are the character number 24, 5 and 38; the character, number 4 and 23 showing no significant differences. Again, we find that, while the species *G. pneumonanthe*, *G. cruciata* and *G. asclepiadea* show close resemblances, *G. ciliata* differs from other species in 10 quantitative and 13 qualitative characters (Table 23).

The result of our study reveals that *G. ciliata* shows a very low degree of affinity with the other three species of *Gentiana*. The same species differs from rest of the three species by more then half (23 characters) of the investigated characters. Thus, its exclusion from *Gentiana* appears to be more probable. We, therefore, support FROELICH (1796), LINK (1821), GRISEBACH (1839) and TUTIN and HEYWOOD (1973) in treating this species under *Gentianella*.

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THE CARPOLOGICAL EXAMINATION OF WILD-GROWING VINE SPECIES OF HUNGARY. II

QUALITATIVE AND QUANTITATIVE CHARACTERISTICS OF VINE SEEDS

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In the second part of this study the author furnish the results of the morphological investigations of vine seeds. First of all, on the basis of the sculptural characteristics and habitus of *V. sylvestris* seeds, classes of characters are set up. The *V. sylvestris* seed is analysed on the basis of the seeds of 1- and 2-seeded berries. The *V. sylvestris* seed is mostly globular; the seed beak is short and conical; the base of the seed is broad, cuneate; the dorsal side is of sharp contour; the chalasa scute is broad-oviform, drop shaped or round; the fosette (of the ventral side) are slightly furcate (or of V shape) or of a parallel course.

The seed weight of the Hungarian types of *V. sylvestris* is between 2.19 and 3.34 gr as against that of *V. vinifera*, which is also grown in Hungary, (cv. Kövidinka, cv. Kadarka, cv. Kékfrankos etc.), having their seed weight between 1.79 and 2.87 gr.

The seed number per berry of *V. sylvestris* plants (on an average of 17 samples) is 1.70. The seed average per berry of the *V. vinifera* variety is higher (2.09). According to the regression examination of the berry volume, in the *V. riparia* sample examined, the increase in seed number per berry and the berry volume are correlated only in the case of two-seeded berries. In *V. sylvestris*, in general, several seeds organize themselves in greater berries.

The qualitative characteristics of the seed

I have virtually grouped morphological characteristics here that cannot be analysed by linear and weight measurements, and on the basis of this I examined and described the seed samples obtained from nine habitats. These diagnostic characters may also be called macroscopic features (since the seeds are small, I have made the analysis by means of a stereomicroscope).

(1) Shape and general outline of the seed. Valuable data were have been already obtained by the synthesis of the linear measures, related to regarding the shape of the seed. On the basis of my own results obtained there, and those of other published works literary data, I have proposed a grouping scheme for a better survey:

The *shape groups* of the seeds are as follows:

(A) Rotundate seed group (*s. rotundati*): For example, (1) *semen cordatus*, (2) *s. rotundatus*, (3) *s. turbinatus*, (4) *s. quadrangularis*, (5) *s. quinquangularis*, etc. Majority of our *V. sylvestris* plants according to their seed shape (71%), in the *s. rotundati* group. For example, plants No 1, and 15 have rotun-

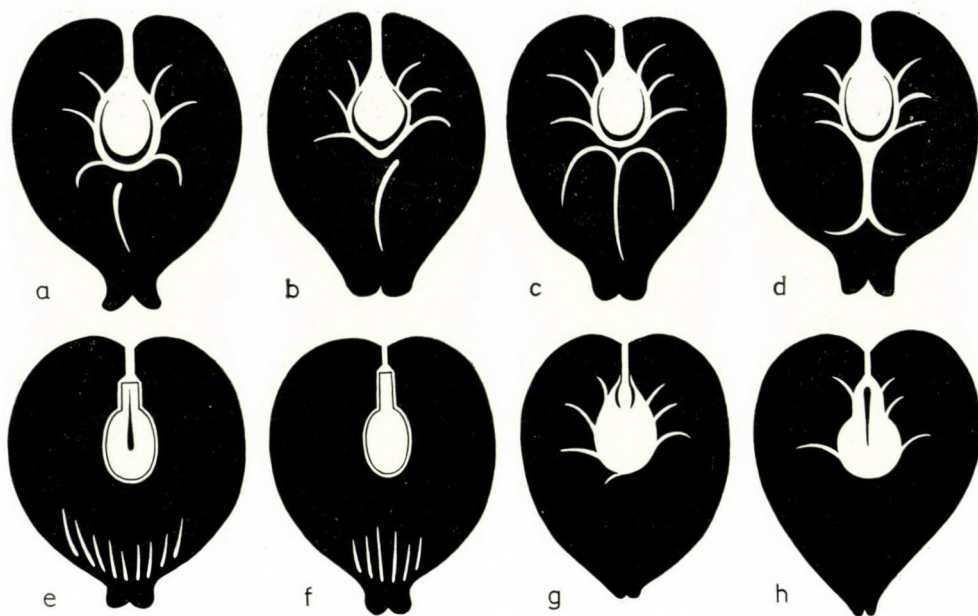



Fig. 16. More important shape characters of *V. sylvestris* and *V. riparia* seeds. Dorsal side: *a—h* chalaza scutate and seed shape habituses; *a—d V. sylvestris, e—h V. riparia* (drawing by I. Kiss)

date seeds; plants No 2, 5, 6 and have quandrangular seeds; plants No 6, 16 and 21 have quinquangular seeds.

(B) Slender, elongate seed group (*s. elongati*); here belong plants No. 10 and 23 (*s. obovatus*), and 19 (*s. ellipticus*), etc.

(*2*) *The apex of the seed* (*apex seminis*) is mostly clearly but shallously incised in the middle. Its two lobes are slightly rounded. The base of the seed (*basis s.*) is characteristic, being usually widely cuneate; it forms the coniform seed rostrum (*rostrum s.*), which is characteristic of the majority of the specimens. Only a few of the plants have a cylindrical (necked) rostrum; it is usually moderately thick and thin rostrum is rare. The surface of the rostrum is often rugose. The location of the furrows also depends on the radial striation running downwards from the base. The rostrum is mostly cylindrical in cross-section, its apex is shallowly bilobate; in 20% of the specimens clavate; in more than half of the specimens straight, in a few cases (see plants 10 and 24) it definitely curves ventrally.

(*3*) *The shape of the seed in a side view* mainly depends variation of the dorsal part, and to less extent on that of the ventral. In the case of one-seeded berries, also the ventral side influences the profile of the seed. With regard to the lateral view, weeds of the following forms can be distinguished:

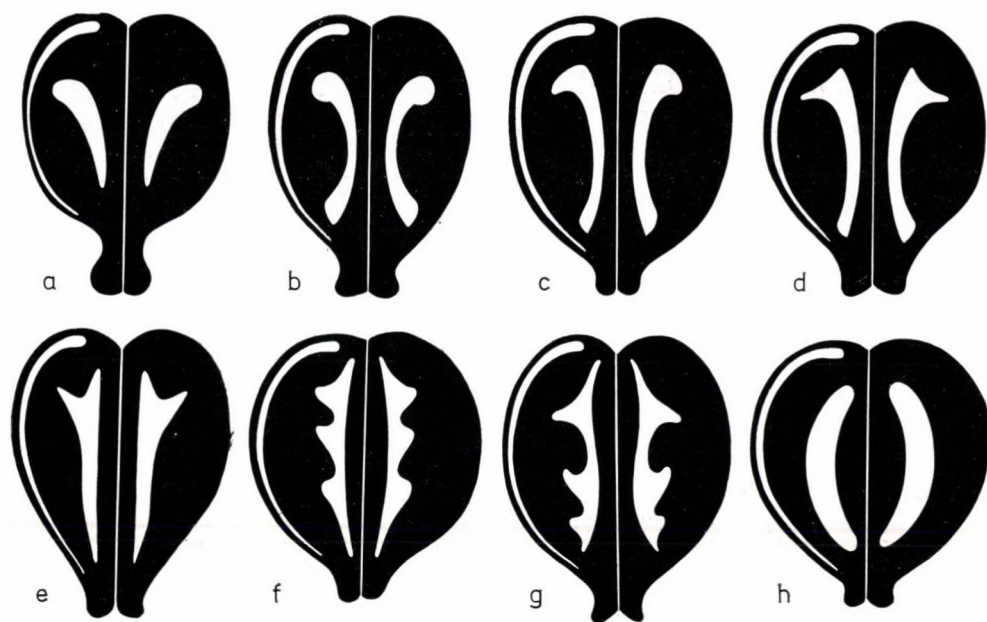



Fig. 17. Ventral side: *a—h* types of fosettes; *a* furcate, *b* turning outwards, bracketed, *c* and *d* hook-shaped, *e* parallel, *f* and *g* branching off, *h* turning inwards, bracketed (drawing by I. Kiss)

(1) ovate,
(2) guttiform,
(3) spider-backed,
  (a) flat spider-backed, etc.
(4) arcuate beetle backed,
  (a) flat beetle-backed, etc.
(5) straight of flat-bodied
(6) bent or crescent-shaped.

In *V. sylvestris*, the general shape profiles are: in one-seeded berries the seed is *ovate*, in two-seeded berries it is *flat beetle-backed* and *flat spider-backed* in *V. riparia:* it is the arcuate or beetle-backed seed. The characteristic spider-backed type occurs in one-third of the specimens. In a lesser quantity the so-called straight (flat)-bodied seeds are also represented.

(4) *The seeds of V. sylvestris* specimens examined are yellowish-brown or chocolate-brown *in colour*. The mature seeds gradually become rust-coloured. The seeds remaining in the dry berry shell preserve their original colour for a longer time. The seeds of *V. sylvestris* are more or less glossy whereas those of *V. riparia* seeds are violet brown and rather dull.

(5) The other characteristic of *V. sylvestris* is *the accentuation or sharpness of the seed sculpture* a general feature in the material examined. By examining

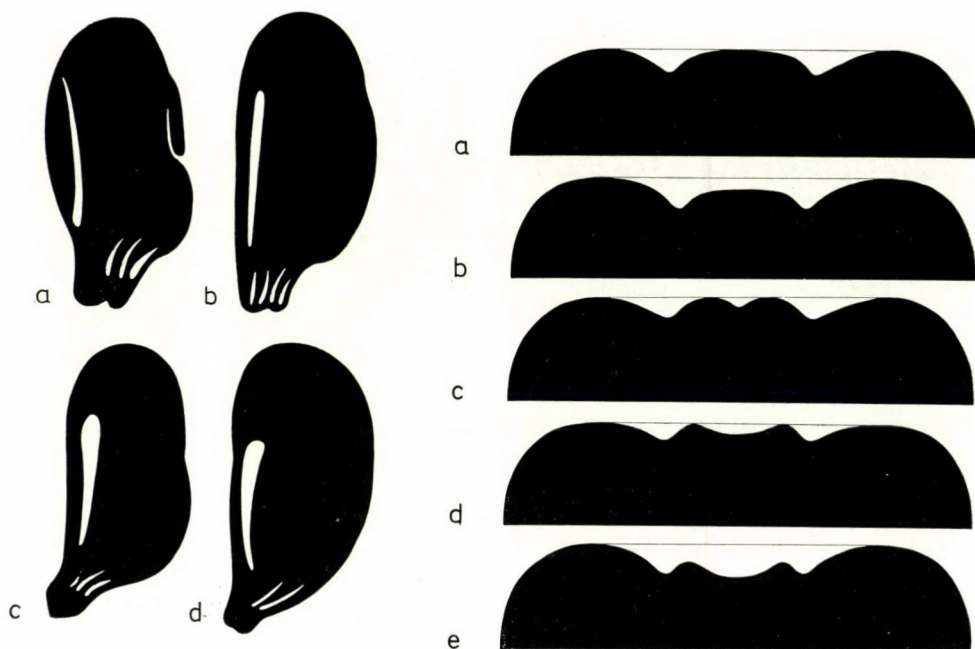



Fig. 17a. 1 Grape seed profiles: *a—c V. sylvestris*, *a* and *c* flattened, spider-backed, *d V. riparia*, ribbed. *2* Chalaza sections, *a* convex, *b* convex, recessed *c—e* concave types (drawing by I. Kiss)

the dorsal side, it could be established that both the dorsal canal (canalis dorsalis) and the chalaza distinctly appear to be of a definite form. The radial striae of the scutum of the chalaza are developed in all directions in 50% of the material; in the seeds of a few plants they are characteristic only on the two sides of the dorsal canal. The dorsal canal (running from chalaza to rostrum) generally does not have any side protuberance (gibba bazalis) either in *V. sylvestris* or *V. riparia.* Only rarely it occurs in sylvestris, primarily in the case of one seeded berries, among our plants, No. 2 has a characteristic side protuberance (Table 3).

(6) A feature regularly in the characterization of *V. sylvestris* is *the shape of the chalazal scutum.* Contrary to the published data, the so-called completely rotundate chalazal scutum was not frequent, it occured only in four specimens. The widely-ovate (guttiform) scutum appeared with a higher frequency.

The chalazal scutum is distinctively deliminited from the sides of the body, by a small horseshoe-shaped or circumambient canal. Its cross-section is usually convex, in a smaller percentage concave. In the latter case a narrow ridge runs around the edge of the canal. In a greater number of specimens, the chalaza scutum was aligned with the surrounding seed surface or it was slightly elevated.

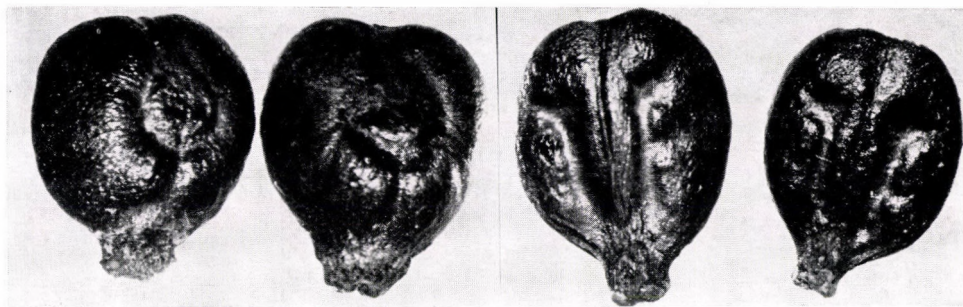



Fig. 18/1

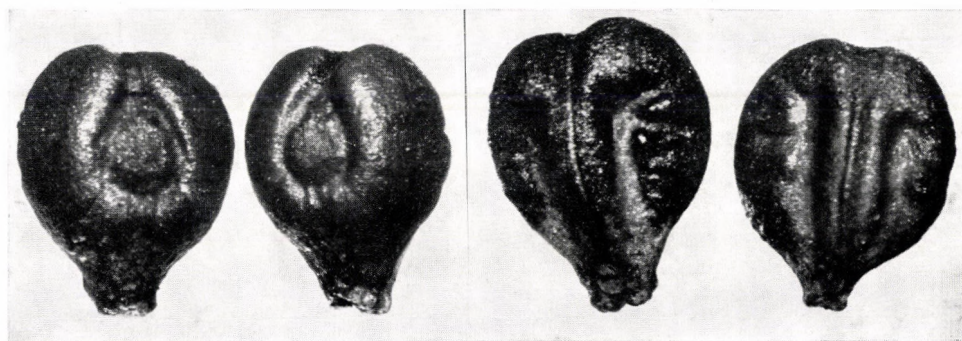



Fig. 18/2

Fig. 18/3

→

Fig. 18. Wild-growing *V. sylvestris* and *V. riparia* seeds, from dorsal and ventral view, in a comparison with the *V. vinifera* L. cultivars grown in Hungary. *V. sylvestris: 1* Szentlőrinc, *2* Simonfa No. 51, *3* Csőszpuszta No. 9, *4* Csőszpuszta No. 10, *5* Háros No. 2, *6* Begov H. YU.; *V. riparia: 7* Háros No. 11/10, *8* Papsziget *9* Háros, No. XV-A; *V. vinifera: 10* cv. Furmint, *11* cv. Hárslevelű, *12* cv. Red tramini

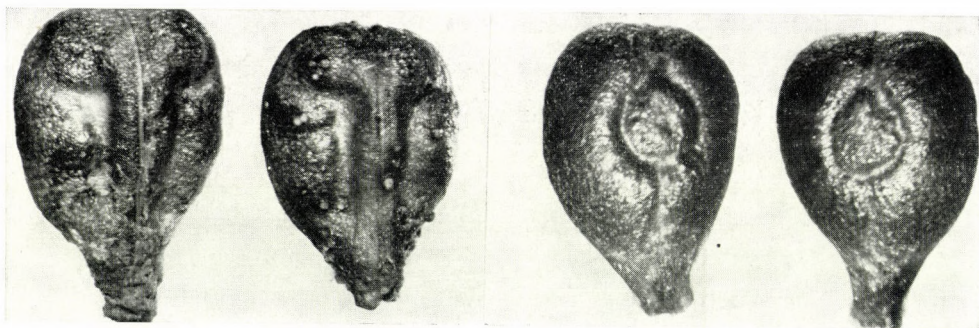
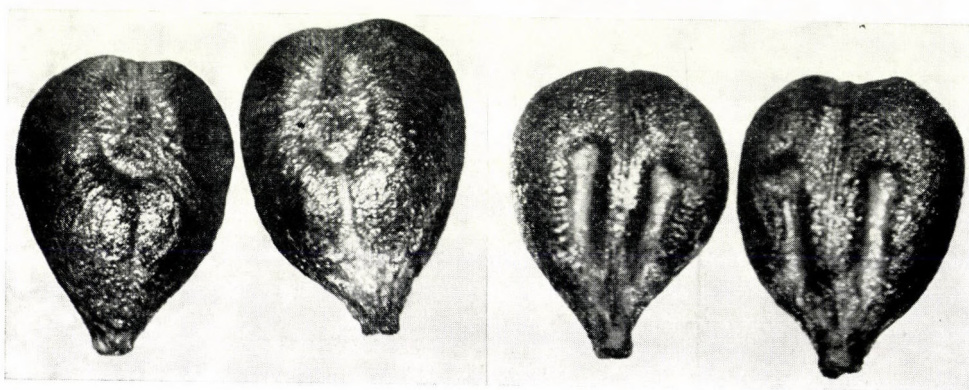



Fig. 18/4

Fig. 18/5

Fig. 18/6

Fig. 18/6

Fig. 18/7

Fig. 18/7

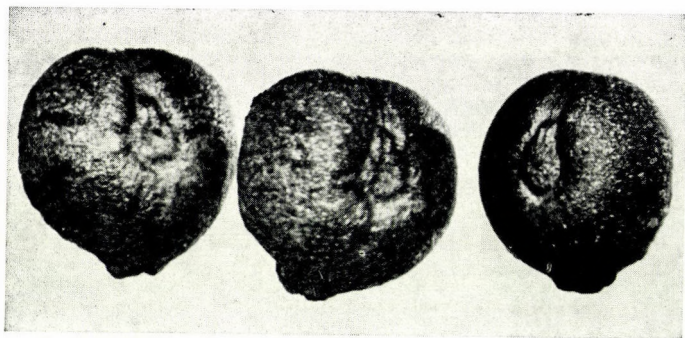
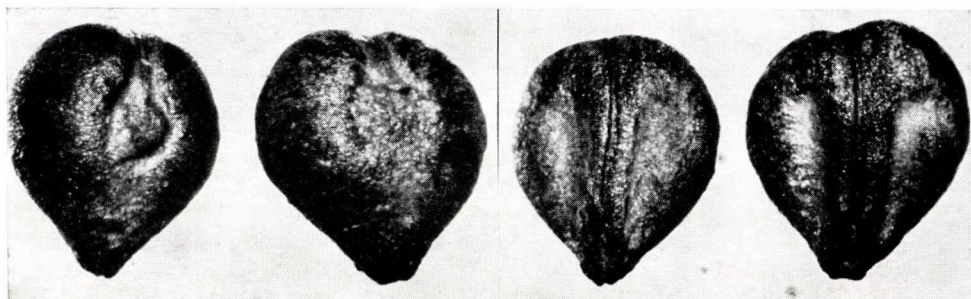



Fig. 18/8

Fig. 18/8

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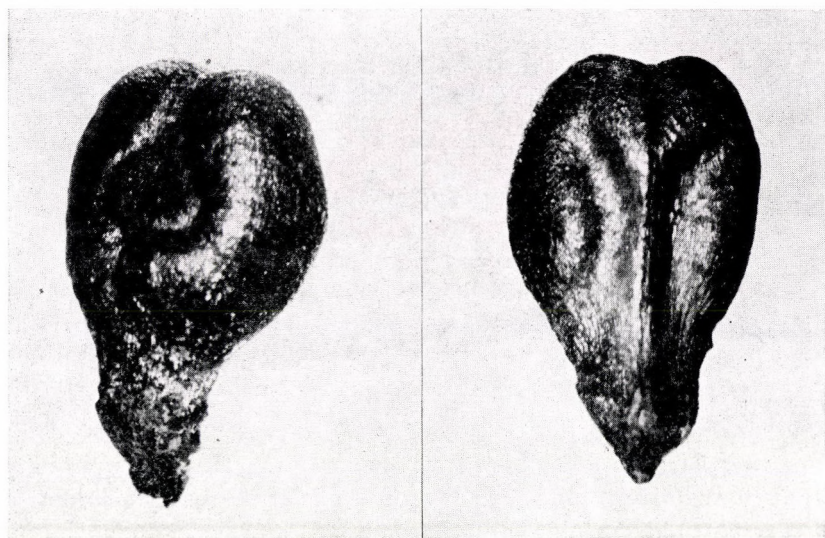
Fig. 18/10
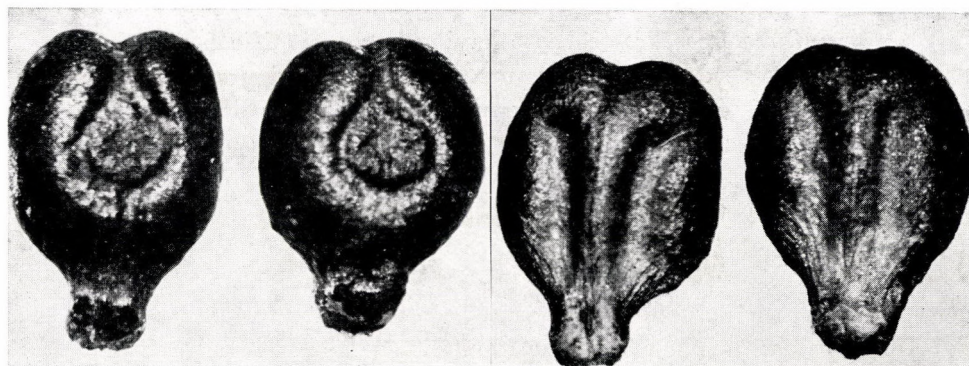
Fig. 18/11
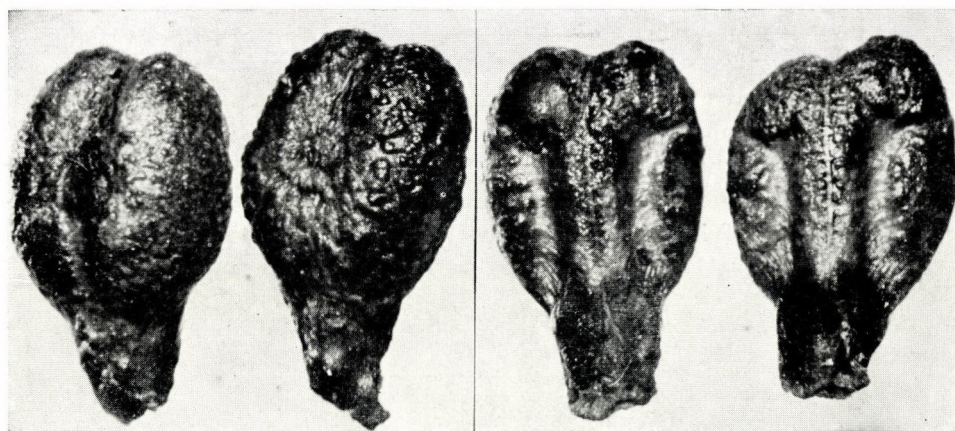
Fig. 18/12

(7) Similarly noticeable features for classification can be found on the *ventral side of the seed*. The most significant among them are the fosettes (*fossae s.*); their systematization improves the description of the seeds to a great extent, and thus are useful in taxonomic works. The decurrence of the fosettes are also to be considered i.e.: *(a) forked (V-shaped)*, *(b) parallel*, *(c) semicircular (bracketed)* turning towards the direction of the raphe. Their shape is simple, straightly canaliculate, shallowly trough-shaped, or branching into lateral furrows. There also occured uncinate and J or L-shaped with a fosettes short basal section; these latter are frequent in *V. sylvestris*.

The decurrence of the furrows is overwhelmingly *furcate* (60—70%) though *parallel* furrows are also frequent; here and there bracketed ventral forrows were also found in *V. sylvestris* and *riparia*. In the seeds of the latter species the ventral furrow is furcate.

The termination of the fosettes can also be characteristic. In our material they usually ended us in the upper third of the body, abruptly or indistinctly (that is, they reached two-thirds of the body). Downwards, they run out in indefinite form onto the rostrum of along the rostrum to the margin of the seed; more rarely, with a definite (pronounced) ending. It should be noted that, in general *unfurcate fosettes* or those having only insignificant side branches *are frequent*. The seeds from "Csőszpuszta" (No. 11) had pronounced furcate (lobate) ventral fosettes. The furrow may be shallow or deep or indistinct. The ventral fosettes of both the *sylvestris* and the *riparia* plants are usually deeper, with sharp, definite outlines.

Summarizing the qualitative characters of the examined *V. sylvestris* stand — in the description of which I have primarily taken into consideration the one-seed and two-seeded berries — it can be stated that the seeds are mostly rotund, their rostrum is short and coniform, their apex with a shallow but wide incision; the end of the apical lobes is straight their angles are slightly rounded. The base of the seed is usually widely cuneate (sloped). The peak of the rostrum is slightly bilobate only rarely incrassate (clavate); the rostrum is straight, rarely arcuate. The shape profile of the seed is mostly flattened spider-backed or flatly beetle-backed. The dorsal side shows a sharp profile; the chalazal scutum is rounded or more frequently widely ovate, guttiform, the canalis dorsalis is conspicuous, the basal protuberance (gibba b.) is rarely developed. The fosettes of the ventral side are mostly furcate (V) or parallel, straightly canaliculate (fossae canaliculatae), uncinate or J- or L-shaped on rarely pronounced and ramifying. The fosettes usually reach two-thirds of the body.

The weight of the seeds

Only a few published data on the weight of the seeds of wild grapes are available. GOETHE (1881) emphasizes that the diagnostic character of weight is extremely constant in the species; it is between 1.4 and 5.8 g in both the European and the American species. POTEBNJA (1911) distinguishes 3 groups of cultivated grapes on the basis of weights: light-weight up to 3 g, medium-weight between 3—4 g, and heavy weight above 4 g, on the basis of the average weight of 100 seeds.

KIRCHHEIMER (1955) published interesting data on the seed weight of *V. sylvestris:* the average weight of the seeds of Upper Rhine plants are 2.54, 2.52, 2.13 g; that of the Danube-bank plants of Upper Austria is 2.53 g, per habitat.

The average weight of the seed specimens of some of the habitats is as follows:

V. sylvestris	g	*V. vinifera* (after FACSAR)	g
10. Csőszpuszta No. 10	2.190	Kövidinka	1.792
— Csőszpuszta No. 3	2.568	Kadarka	2.584
20. Feketeerdő No. 4	3 345	Kékfrankos	2.871
23. Háros No. 2	2.826	Medoc noir	2.140
V. riparia		*Stock-vines*	
10. Háros No. 3/75	1.862	1616 C.	2.039
— Háros H—11/10.17	1.132	T—K 588	2.047
— Csongrád No. 5a	1.405		
— Mindszent No. 8/75	1.742		

It is remarkable that the tiny seeds of *V. riparia* also show a relatively great variability. *V. sylvestris* specimens Nos 20 and 23, from areas along the Danube, are of varying weights and they are rather heavier in comparison to the data published by KIRCHHEIMER. In all specimens, the seeds originating from four-seeded berries were always lighter than those from one-seeded or even from three-seeded berries.

The number of seeds per berry

Seed production is considered among the essential characteristics of the wild vine species, as in the case of *basic species* from two viewpoints. One should like to know to what extent the seed number per berry is a typical, constant diagnostic characteristic of the various species. Is there any difference between the populations of the species living in different conditions. Further what role is played by seed production in the survival of the species and in eventual tendencies to increase the habitat. Both species discussed

Plate VI. The last pistillate *V. sylvestris* plant of the Island of Háros (alongside the Danube (painted by Mrs LEXA)

in this paper investigated this enquiry; *V. sylvestris* because it is becoming extinct, and *V. riparia* because it attracted attention by extending its range.

Kirchheimer (1955) examined *V. sylvestris* materials originating from areas similar to the habitats of our wild vines. According to his data, the seed number per berry of *V. sylvestris* inhabiting groves along the Danube in Lower Austria is as follows:

Habitats and berry number

Seed number	*Stadt (400)* %	*Eckartsau* (900) %
1	44.0	42.6
2	21.5	32.0
3	22.0	18.3
4	11.5	6.3
5	1.0	0.6
6	—	0.2

The author obtained similar seed ratios in the Upper Rhine habitats used for comparison. For example, 63% of the material collected from the island in the Rhine at Ketsch consisted of 1- and 2-seeded berries; only 25% of it was 3-seeded. He examined materials of a similar distribution near Germersheim (1- and 2-seeded 68%, 3-seeded 15%). In the material near Speyer (Otterstadt), 80% of the berries was 1- and 2-seeded, only 9% of them contained 3 seeds.

I have compiled tables of the seed production of the wild-growing vines of Hungary (Tables 7, 8). It appears from both tables that there are considerable differences between the two species concerning seed number per berry of the specimens, either between the two species or within the two species themselves. In addition, differences occur within the stands of the various habitats. Comparing Kirchheimer's and our data, obtained from the plants along the banks of the Danube, the percentage of seed production per berry shows a surprising picture, meaning almost a coincidence of data. In the case of specimen No. 13 (Feketeerdő, No. 4, near Mosonmagyaróvár), the percentage ratio of the 1- and 2-seeded berries is 86%, in specimen No. 14 it is 65%, in specimen No. 15 it is 70%.

It is worth while to compare the specimens 15 and 16, since the plant is the same, the only difference being that the material of No. 16 was collected in 1969, while that of No. 15 in 1975. The difference is not substantial: for example, the number of 1-seeded berries is 45 and 44%, that of the two-seeded berries is 25 and 32%, that of the 3-seeded berries is 18 and 16%. Considering the average of the 17 specimens (1.705), I think that these seed productions are relatively very good.

Table 7

Seed number per berry in V. sylvestris specimens obtained in Hungary and from abroad — Bulgaria (BG), Roumania (R) and Yugoslavia (YU)

		1-seeded berry		2-seeded berry		3-seeded berry		4-seeded berry		5-seeded berry		6-seeded berry		Average	n
		n	%	n	%	n	%	n	%	n	%	n	%		
1.	Kesztölc No. 4	9	36.0	5	20.0	6	24.0	4	16.0	1	4.0	—	—	2.32	25
2.	No. 14	7	70.0	3	30.0	—	—	—	—	—	—	—	—	1.30	10
3.	No. 36/74	11	40.8	12	44.4	4	14.8	—	—	—	—	—	—	1.74	27
4.	No. 50	4	40.0	6	60.0	—	—	—	—	—	—	—	—	1.60	10
5.	Szendehely III.	13	52.0	5	20.0	6	24.0	1	4.0	—	—	—	—	1.40	25
6.	Szendehely XI.	5	20.0	15	60.0	5	20.0	—	—	—	—	—	—	2.00	25
7.	Csőszpuszta No. 3/75	33	33.0	43	43.0	14	14.0	9	9.0	1	1.0	—	—	2.02	100
8.	No. 9/75	41	58.6	22	31.4	7	10.0	—	—	—	—	—	—	1.51	70
9.	Botykapeterd No. 1/68	535	53.5	295	29.5	138	13.8	32	3.2	—	—	—	—	1.67	1000
10.	Simonfa No. 1	15	60.0	6	24.0	4	16.0	—	—	—	—	—	—	1.56	25
11.	No. 51	11	44.0	9	36.0	4	16.0	1	4.0	—	—	—	—	1.80	25
12.	No. 53/24	39	21.4	74	40.7	53	29.1	15	8.3	1	0.5	—	—	2.25	182
13.	Feketeerdő No. 4	110	57.0	56	29.0	27	14.0	—	—	—	—	—	—	1.56	193
14.	Papsziget No. 1	91	54.5	36	21.5	29	17.4	9	5.4	1	0.6	1	0.6	1.77	167
15.	Háros No. H-S2/75	170	45.3	94	25.0	70	18.7	40	10.7	1	0.3	—	—	1.95	375
16.	Háros No. H-S2/69	180	44.0	132	32.3	69	16.8	28	6.8	—	—	—	—	1.86	409
17.	Háros No. 100	402	80.5	91	18.0	5	1.0	2	0.5	—	—	—	—	1.21	500
	Σ	1676		904		441		141		5		1		1.70	3168
	%	53.00		28.50		14.00		4.45		0.15		0.03			
1.	BG KAM. No. 1	31	57.0	12	22.0	8	14.0	3	5.0					1.68	54
2.	R Toplet No. 5	75	62.0	37	31.0	8	7.0	—	—	—	—	—	—	1.50	120
3.	YU MAC Vinica No. 2	547	66.4	240	29.1	34	4.1	2	0.2					1.38	823
4.	YU MAC Blatec No. 4	374	65.0	84	30.0	9	5.0	1	0.7	—	—	—	—	1.22	468
5.	YU B Zenica VI.	340	40.0	385	45.0	111	13.0	15	2.0	—	—	—	—	1.76	851
6.	YU-B Doboj IV.	258	75.0	67	20.0	15	4.0	4	1.0	—	—	—	—	1.31	344
	Σ	1625		825		185		25						1.48	2660
	%	61.09		31.01		6.95		0.93							

Table 8

Seed number per berry of V. riparia plants growing wild along the rivers Danube, Tisza and Bodrog

		1-seeded berry		2-seeded berry		3-seeded berry		4-seeded berry		5-seeded berry		6-seeded berry		Average	n
		n	%	n	%	n	%	n	%	n	%	n	%		
	Danube														
1.	Háros R2	152	43.2	129	36.7	44	12.5	21	5.9	6	1.7	—	—	1.86	352
2.	R5	398	65.9	178	29.4	24	4.0	4	0.7	—	—	—	—	1.39	604
3.	R7	186	38.3	210	43.2	74	15.2	16	3.3	—	—	—	—	1.83	486
4.	No. 21/68	190	38.5	188	38.1	93	18.9	22	4.5	—	—	—	—	1.89	493
5.	No. 22/68	271	41.7	262	40.3	94	14.5	23	3.5	—	—	—	—	1.79	650
6.	No. 23/68	383	39.4	457	47.0	113	11.6	19	2.0	—	—	—	—	1.86	972
7.	No. 24/68	244	40.7	281	46.8	73	12.2	2	0.3	—	—	—	—	1.72	600
8.	No. 25/68	296	59.2	147	29.4	49	9.8	8	1.6	—	—	—	—	1.53	500
9.	No. 26/68	78	9.0	230	26.3	354	40.5	211	24.2	—	—	—	—	2.79	873
10.	No. 3/75	29	29.0	31	31.0	25	25.0	13	13.0	1	1.0	1	1.0	2.29	100
11.	No. 11/75	33	33.0	44	44.0	20	20.0	3	3.0	—	—	—	—	1.93	100
12.	K.V/75	179	33.9	253	47.9	88	16.6	8	1.5	—	—	—	—	1.85	528
13.	HA-105	152	38.0	166	41.5	54	13.5	28	7.0	—	—	—	—	1.89	400
14.	HA-104	184	36.8	207	41.4	86	17.2	23	4.6	—	—	—	—	1.89	500
	Tisza														
15.	Tőserdő No. K2	13	13.0	32	32.0	37	37.0	17	17.0	1	1.0	—	—	2.61	100
16.	Mindszent No. 6/75	41	41.0	42	42.0	12	12.0	5	5.0	—	—	—	—	1.81	100
17.	No. 8/75	10	10.0	39	39.0	37	37.0	14	14.0	—	—	—	—	2.55	100
18.	No. 10/75	148	69.1	54	25.2	10	4.7	1	0.5	1	0.5	—	—	1.37	214
19.	Csongrád III/75	28	21.9	52	40.6	41	32.0	5	3.9	2	1.6	—	—	2.22	128
	Bodrog														
20.	Bodrogkeresztúr No. 7	35	63	228	40.7	201	35.9	96	17.1	—	—	—	—	2.63	560
	No. 9	215	26.6	398	49.2	167	20.7	28	3.5	—	—	—	—	2.01	808
	Σ	3265		3628		1696		567		11		1		1.956	9168
	%	35.61		39.57		18.49		6.18		0.11		0.01			

Table 9

Seed number by berry of the general V. vinifera cultivars growing in Hungary

		1-seeded berry		2-seeded berry		3-seeded berry		4-seeded berry		Average	n
		n	%	n	%	n	%	n	%		
1.	Kövidinka 1972	51	10	129	26	187	37	133	27	2.80	500
2.	Olaszrizling 1972	81	16	230	46	145	29	44	9	2.30	500
3.	Kadarka 1972	163	33	231	46	90	18	16	3	1.91	500
4.	Kékfrankos 1972	280	56	165	33	45	9	10	2	1.57	500
5.	Rizlingszilváni 1974	8	16	25	50	11	22	6	12	2.30	50
6.	M. Ottonel 1974	33	33	44	44	18	18	5	5	1.95	100
7.	Chasselas 1974	60	60	27	27	13	13	—	—	1.53	100
8.	Red tramini 1974	81	81	18	18	1	1	—	—	1.20	100
9.	Bánáti rizling 1974	22	22	36	36	31	31	11	11	2.31	100
10.	Olaszrizling 1974	19	19	41	41	30	30	10	10	2.31	100
	Σ	798		946		571		235	—	2.09	2550
	%	31.29		37.09		22.39		9.21			

The *V. sylvestris* plants do not bring a better yield or ratio in more southern areas (for example, in Yugoslavia) either. According to the table, the smallest average per berry (1.22) occurs in the Macedonian grapes. Their averages per berry — 1.38—1.76 — are very low, considering the fact that the temperature conditions are much more favourable there. Probably the dioecious nature of the vine plant is one of the causes that this relatively low seed production remains on the same level.

Another interesting phenomenon is that in a few habitats in Hungary (for example, No. 1, Kesztölc 4, in the Pilis Mountain; and No. 7, Csőszpuszta 3, in the Bakony Mountains), the average value of seed production per berry in *V. sylvestris* is above 2.0. The average of *V. riparia* specimens in essence also reaches that value, but the interval between the extreme average values is much higher in this species, even between two plants of the same habitat. On the island of Háros in the Danube, there occur seed averages of 1.39 and 2.79 per berry, but the situation is very similar also in the stands along the river Tisza.

In general, the average of 3 seeds per berry always presupposes that the sum of the ratio of the two-seeded and three-seeded berries be greater than that of the one-seeded and two-seeded ones together. The more abundant seed production of *V. riparia* also contributes to the rapid and relatively mass renewal proliferation of this plant. This is a condition of only a smaller importance in the mass proliferation of this species; the decisive role as a whole is played by the relatively extensive resistance of the plant against diseases and insect pests and by its special ecological requirements.

Finally, we summarized in a separate table the data of *V. vinifera* cultivars (Table 9) which were regularly used as control material in our *V.*

Plate VII. Vitis riparia with branched and loose clusters, from the plains between the Bodrogs (Tokaj, Bodrogkeresztúr)

Plate VIII. Vitis riparia from the willow groves alongside the river Tisza, from the side of Csongrád (painted by V. CSAPODY)

sylvestris researches. Their seed average per berry is above 2.0. The higher seed average per berry of *V. vinifera* varieties, as deoecious plants, deserves attention in any further *V. sylvestris* researches.

Correlations between seed number per berry and berry size

Berry size and the seed number per berry concern primarily to cultivated plant taxonomists and archeobotanists and last but not least specialists in the field of practice. As a consequence of the allometric growth process, the utilized organs of a plant may grow to a multiple extent and more powerfully than the whole plant, or its other, non-utilized parts. The berry size of the vine plant has also increased considerably in the wake of several thousands years of cultivation and selection. According to NEGRUL' (1960), parallel with the increase in size of the berry the seed also became greater. He confirmed it by calculations (correlation coefficient $R = 0.66 \pm 0.048$; each mm of berry increase represents a 0.27 mm increase in the seed). At the same time, of several species, relatively large berries in seeds only of small size develop. The latter statement has previously been proved also in the two basic species.

Recently, SCHUMANN (1972, 1973) dealt with the effect of seed number on the size of the berry and its guice production in *V. vinifera*. His results corroborate former researches (MÜLLER—THURGAU 1908 etc.), according to which berries with a greater seed number are larger than those with a smaller seed number, but their economic value may be lesser. The size values related to one seed the species, and showed a linear correlation with a 0.21—0.67 cm^3 increase in value.

Several authors (e.g. NEGRUL' l.c. LEVADOUX, l.c.) deduce the varieties of *V. vinifera* directly from the population of *V. sylvestris*. Therefore we felt it necessary to establish the correlation between wild seed number per berry and berry size also in some representatives of the parent vine species. We have also drawn into our investigations three *V. riparia* types (Háros No. 3, Háros No. 11/10 and Háros No. XV/A), in addition to the four *V. sylvestris* forms (Csőszpuszta No. 3, Csőszpuszta No. 9, Feketeerdő No. 4, Háros No. 2). With the exception of one sample the specimens appear in the table of seed number per berry.

The examinations, conducted by means of regression analyses, have in general confirmed the results obtained for the *V. vinifera* varieties (SCHUMANN, l.c.). The length of the berry and the increase in seed number per berry showed a positive correlation, which is generally uni-directional in all examined plants and which proves the correctness of our evaluation of the results obtained during our studies and measurements. As has been indicated earlier, in the majority of specimens most of the seeds grow in general in the largest berries.

Table 10

Regression equations, coefficients and the data pairs of the correlation between berry length and seed number per berry (see. Fig. 17)

Vitis sylvestris specimens	Correlation coefficient	Regression coeff. and significance	Regression equation	Data pairs
Csőszpuszta No. 3	r = + 0.67	b = 0.78 ± 0.086	Y = 0.78 X—3.87	n = 100
Csőszpuszta No. 9	r = +0.58	b = 0.56 ± 0.094	Y = 0.56 X—2.61	n = 70
Feketeerdő No. 4	r = + 0.70	b = 0.62 ± 0.063	Y = 0.62 X—3.73	n = 100
Háros No. 2	r = + 0.45	b = 0.48 ± 0.094	Y = 0.48 X—1.69	n = 100

Table 11

Regression equation, coefficients and the data pairs of the correlation between berry diameter and seed number by berry (see. Fig. 18)

Vitis sylvestris specimens	Correlation coefficient	Regression coeff. and significance	Regression equation	Data pairs
Csőszpuszta No. 3	r = + 0.78	b = 0.68 ± 0.054	Y = 068 X—3.55	n = 100
Csőszpuszta No. 9	r = + 0.77	b = 0.62 ± 0.060	Y = 062 X—3.25	n = 70
Feketeerdő No. 4	r = + 0.81	b = 0.68 ± 0.048	Y = 0.68 X—4.42	n = 100
Háros No. 2	r = + 0.56	b = 0.57 ± 0.085	Y = 0.57 X—2.31	n = 100

Table 12

Regression equation, coefficients and data pairs of the correlation between berry length and seed number per berry (see Fig. 19)

Vitis riparia specimens	Correlation coefficient	Regression coeff. and significance	Regression equation	Data pairs
Háros No. 3	r = + 0.85	b = 1.01 ± 0.063	Y = 1.01 X—4.92	n = 100
Háros No. 11/10	r = + 0.90	b = 1.27 ± 0.062	Y = 1.27 X—6.59	n = 100
Háros No. XV-A	r = + 0.88	b = 0.75 ± 0.056	Y = 0.75 X—3.44	n = 50

Table 13

Regression equations, coefficients and data pairs of the correlaton between berry diameter and seed number per berry (see Fig. 19)

Vitis riparia specimens	Correlation coefficient	Regression coeff. and significance	Regression equation	Data pairs
Háros No. 3	r = + 0.83	b = 0.90 ± 0.051	Y = 0.90 X—4.62	n = 100
Háros No. 11/10	r = + 0.91	b = 1.10 ± 0.050	Y = 1.10 X—5.77	n = 100
Háros No. XV-A	r = + 0.91	b = 0.63 ± 0.039	Y = 0.63 X—2.99	n = 50

It also has been pointed out earlier that the seeds become shorter in the case of 3—4 seeds per berry and that grow more slowly. Theoretically, therefore, the flesh meat of the berry may increase at a greater proportion in the case of berries with higher seed-number (3—5) than in the case of 2- and 3-seeded berries.

The inter- and infraspecific deviations an infraspecific ones are worthy of special attention in the regression analysis. The graphs show conspicuously regularities which — although showing errors to a certain extent, yet at the same time, is characteristic of the two species, and manifesting itself in the deviations (Figs 17—20).

The line demonstrating the correlation between berry length and seed number per berry of "Csőszpuszta No. 3" among the *V. sylvestris* specimens is the most abrupt; it is characteristically aligned with the direction of the lines of *V. riparia* specimens (Fig. 17). The berry of this plant can be consid-
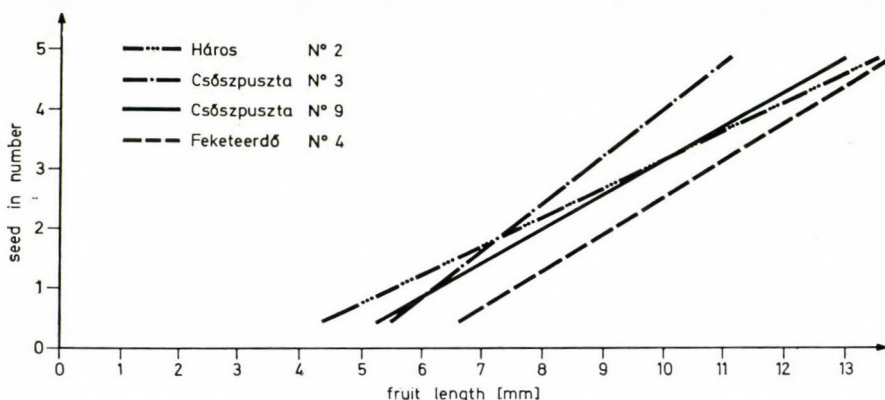
Fig. 19. Correlation between berry length and seed number per berry in *V. sylvestris* specimens
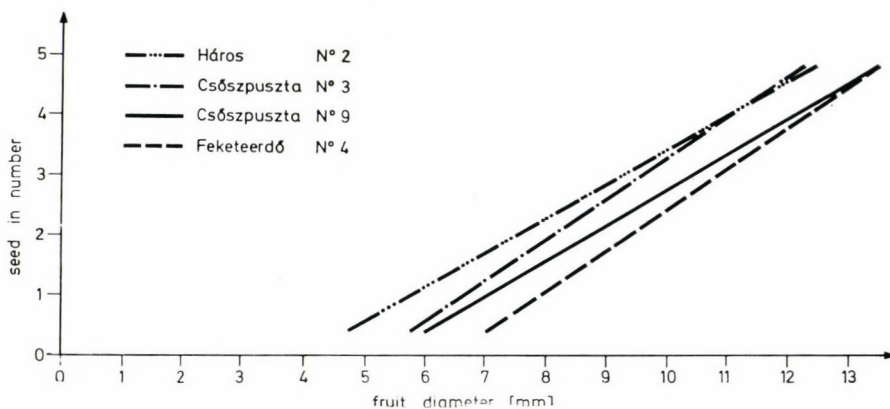
Fig. 20. Correlations between berry diameter and seed number per berry in *V. sylvestris* specimens

ered to be of medium size on the level of wild vines. In general, the first viable seed can be expected to appear at 5.0 and 6.5 mm lengths, while between 7.0 and 8.0 mm two viable seeds may appear. An individual new seed usually appears at a berry length increase of 1.3 mm which is 24% of the one-seeded berry and 13% of the two-seeded berry. Incidentally, 76% of the berries are one- or two-seeded berries.

The relationship between berry length and seed number is expressed by a less abrupt line of the two *V. sylvestris* plants which grow along the Danube (No. 20, Feketeerdő No. 4; No. 23, Háros No. 2). These have larger berries and bigger seeds; in most of the cases, a new seed can be expected at a 1.6 and a 2.1 mm increase. In these plants, a greater increase in berry size occurs, because the increase in length is quicker than the increase in seed number rate.

Although the regression of the former group is significant at a P = 0.1%
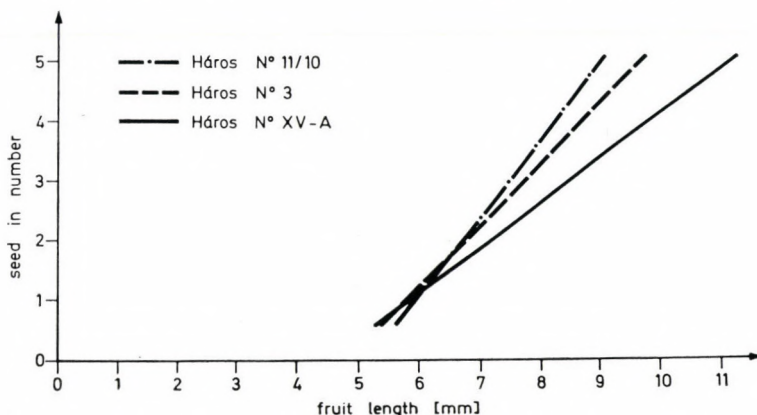
Fig. 21. Correlations between berry length and seed number per berry in *V. riparia* specimens
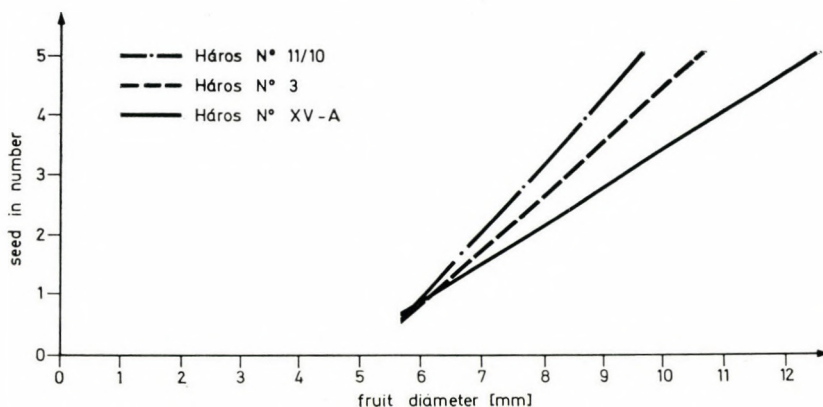
Fig. 22. Correlations between berry length and seed numbers per berry in *V. riparia* specimens

level, there is an even closer relationship between berry width and seed number. The difference is little between the courses of the lines, they are located much closer to each other. The next seed can be organized at an increase in volume of 1.47 (No. 3) and 1.75 (Háros No. 2) mm on the average.

The values of the *V. riparia* specimens show an even closer correlation, their lines are nearly equally sleep. On the other hand, we may except here a greater increase in width only on the appearance of the next seed (Háros
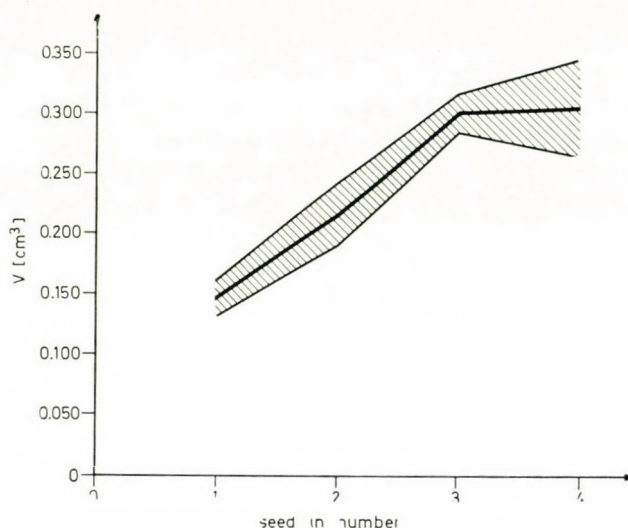
Fig. 23. Correlations between seed number per berry and berry volume averages, with confidence interval (*V. riparia*, 'Háros' K. V./75)

No. 3 = 1.11 mm; Háros No. 11/10 = 0.94 mm; Háros XV—A = 1.59 mm). As far as the length of the berry is concerned, nearly identical data are obtained* 0.99 mm in Háros No. 3, Háros No. 11/10 and at 1.33 mm in Háros No. XV—A.

The regression relation presented is most unambiguous; it shows the regularity characteristic of the basic vine species; the regression equation reacts especially sensitively on the correlative changes between berry width and seed number.

As has already been mentioned in several specimens the berry length decreases together with the increase in seed number per berry in the same plant (for example, in the case of 3- or 4-seeded berries). We presumed that the length and diameter of the berry also decreased. Information was sought with regard to this process as well. Therefore we carried out several kinds of volume measurements (cm^3) for the berries and calculations related to seed number. The results of the calculations related to the measurements of berries

* The appearence of the next seed may be expected.

of one of the Danube-bank *V. riparia* specimens (Háros K. V./75) will be given below. In the course of these experiments we measured the volume of 531 vine berries and counted the seeds per berry, and subsequently we calculated the average berry volumes corresponding to the various seed numbers, together with the confidence intervals belonging to them.

Under the headings of the volume groups two kinds of percentage data are given. The percentages of the second row have to be summed up vertically and evaluated (Table 14).

Among the values of berry volume, berry volume averages belonging to seed groups No. 1, 2 and 3 differ significantly at probability level P = 5%.
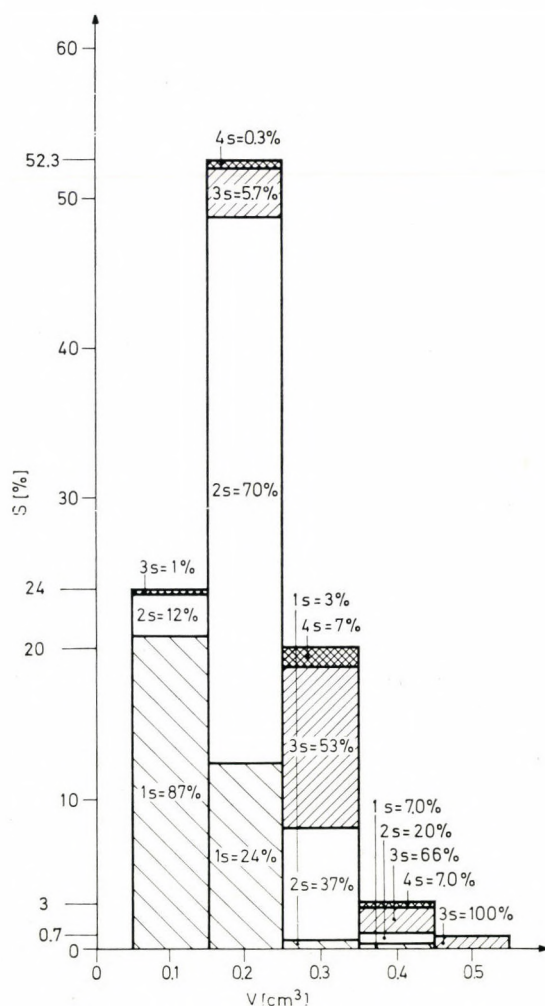
Fig. 24. Percentage distribution of berry volume classes of different seed numbers in 'Háros K. V./75' of *V. riparia*

There is no significant difference between the berry volume averages of seed groups Nos 3 and 4. The confidence intervals have been calculated by means of the equation $\overline{V} \pm t_{5\%} S_{\overline{V}}$, where V is the average volume of the seednumber group, $s_{\overline{V}}$ is its error, $t_{5\%}$ is the value of t appearing in the Table.

The diagrams call attention to a peculiar phenomenon. About one half of the 531 berries examined belongs to the 0.2 cm³ category, while the number of the 0.4 and 0.5 cm³ size berries is very small (Fig. 22).
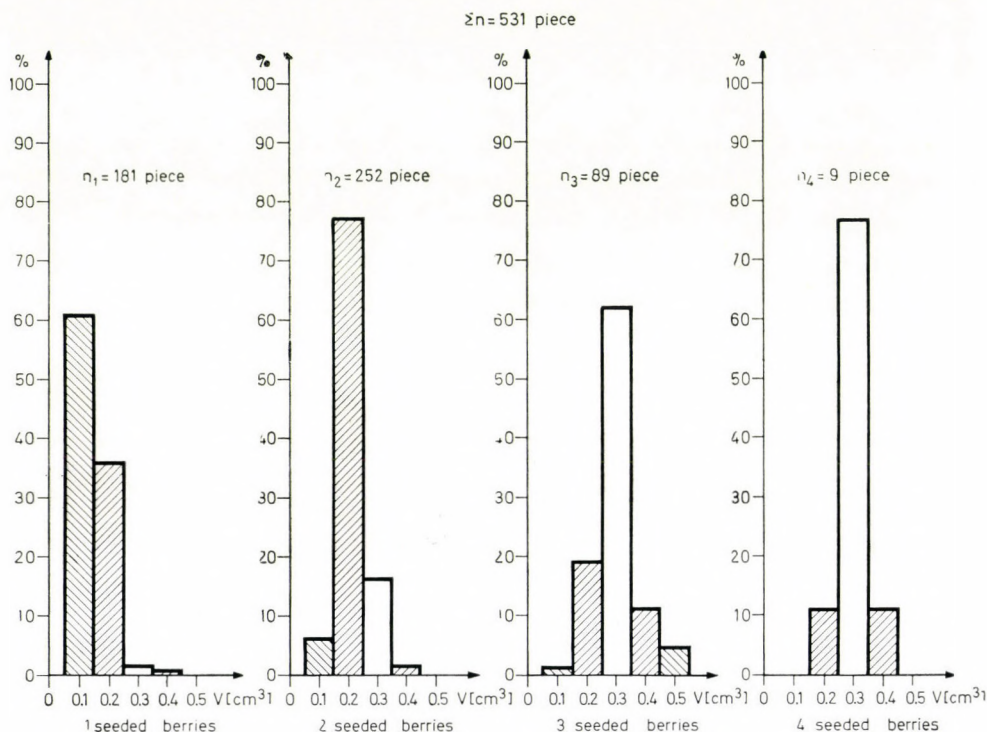
Fig. 25. Percentage distribution according to seed number per berry in *V. riparia* 'Háros K. V./75' berries of different volume

One-seeded berries appear in all classes, but virtually 97% belong to the 0.1 and 0.2 cm³ categories, and from this 61% only to the first category. It is characteristic that in the highest category (0.5 cm³), only 3-seeded berries can be found; the overwhelming majority of the 4-seeded berries is in the 0.3 cm³ category (Figs 22 and 23). However, attention must be called to the fact that the number of 4-seeded berries was very small ($n = 9$) in the specimens, and so this result refers rather to the natural variability only; the volume ratio of the 4-seeded berries can be accepted only conditionally.

The diagram demonstrating the correlations between average berry volume and seed number per berry substantiates several of our carpological

Table 14

Correlation data between seed number per berry and berry volumes (cm^3) in V. riparia (Háros K. V./55)

Seed number per berry	Average berry volume, cm^3	Confidence interval	Frequency by volume groups, cm^3					
			0.1	0.2	0.3	0.4	0.5	
1	$h_1 = 0.1304$		111	66	3	1	—	No.
$n_1 = 181$	0.146	±0.025	0.61	0.36	1.65	0.5	—	%
$\% = 34$	$h_2 = 0.1616$		87.4	23.7	2.8	6.6	—	%
2	$h_1 = 0.1902$		15	194	40	3	—	No.
$n_2 = 252$	0.216	±0.0258	5.9	76.9	15.87	1.19	—	%
$\% = 47$	$h_2 = 0.2418$		11.8	69.7	37.3	20.0	—	%
3	$h_1 = 0.2855$		1	17	57	10	4	No.
$n_3 = 89$	0.3005	±0.015	1.1	19.0	64.0	11.2	4.49	%
$\% = 17$	$h_2 = 0.3155$		0.7	6.0	53.2	66.6	—	%
4	$h_1 = 0.2649$		—	1	7	1	—	No.
$n_4 = 9$	0.3055	±0.0406	—	11.1	77.7	11.1	—	%
$\% = 2$	$h_2 = 0.3461$		—	0.3	6.5	6.5	—	%
$\Sigma = 531$			127	278	107	15	4	No.
			23.9	52.3	20.0	2.8	0.7	%

investigations made so far. Berry size — the average volume — increases in a nearly identical proportion from the seedless berry through the one-seeded berry to the 3-seeded one (the difference is significant on a $P = 5\%$ probability level). However, if more than three seeds grow in the berry, then the growth becomes highly insignificant, or the size and weight of the berry show a decreasing tendency. A reliable evaluation of the volume of 4-seeded berries is aggravated here by the fact that there were only relatively few 4-seeded berries in the specimens. This is rather conspicuously illustrated also by the remarkably widening confidence band.

Summary

The botanico-carpological analysis of the wild-growing vine species of Hungary has provided useful data to the solution of the following:

(1) Despite the fact that the ecological requirements of *Vitis sylvestris* and *V. riparia* are close to each other, they are different, since *V. sylvestris* showed adjustement not primarily to an uptake of great quantities of water but to the more balanced ecological conditions.

(2) The fruit clusters of *Vitis* species in the area studied are loose, alate, their berries are blue, bluish black or black; no white-berreid forms have been detected. It is characteristic that *V. sylvestris* shows hardly any difference in seed number compared to *V. vinifera*, while its cluster size is only one half or one-third of *V. vinifera*, and the weight of its berries only 25—39%.

(3) The diagnostic character of the wild grape seeds are of primarily significance even today in the interspecific taxonomy of vine. The typical features useful for distinguishing the species are as follows the shape of the seed in dorsal and lateral views; the length of the rostrum, and the sculpture of the dorsal and ventral sides. The seed of *V. sylvestris* is characterized by a definite and distinct sculpture and the short rostrum, the rotund or widely-ovate chalaza scutum; the furcate or parallel decurrence of the ventral furrows reaching the upper two-thirds of the seed body.

(4) The seed measurements make especially indices (length/width, width/length, rostral length/seed length) possible a more accurate separation and they are characteristic of the various species. The close relationships between *Vitis sylvestris* populations growing in various parts of Europe can be conspicuously demonstrated by means of these indices.

(5) The seed number per berry is also characteristic of the species examined.

A correlation can be deduced between the seed number per berry and berry measurements also in the wild berries. The volume of berry flesh related to one seed decreases with the increase of seed number.

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APPENDIX

Vitis vinifera varieties used in the comparison
Wine grape varieties

1. Bouvier — 1 — (Precoce de Bouvier blanc)
2. Medoc — 2 — (Mondeuse noir)
3. Korai piros Veltelini (Veltelin rouge précoce)
4. Rizlingszilváni — 3 — (Müller Thurgau blanc)
5. Ottonel muskotály — 4 — (Muskát Ottonel blanc)
6. Pinot = Kisburgundi — 5 — (Noirien, Pineau noir)
7. Chardonnay = Burgundi — 6 — (Chardonnay blanc)
8. Oporto — 7 — (Autrichien, Portugais bleu)
9. Leányka (H) — 8 —
10. Szilváni — 9 — (Sylvain bleu, rouge, vert)

11. Melon — 10 — (Melon)
12. Tramini — 11 — (Tramente rose)
13. Ezerjó (H) — 12 —
14. Sémillon (Sémillon blanc)
15. Sauvignon — 13 — (Gros Sauvignon)
16. Piros Veltelini (Veltelin rouge)
17. Zöld Veltelini (Ranfol blanc)
18. Kékfrankos — 14 — (Franconien noir)
19. Muskotály — 15 — (Muscat Frontignan noir)
20. Cirfandli — 16 — (Zierfandler rouge)
21. Olaszrizling — 17 — (Risling italien blanc)
22. Rajnai rizling — 18 — (Risling blanc)
23. Hárslevelű (H) — 19 —
24. Furmint (H) — 20 —
25. Cabernet (Cabernet franc)
26. Cabernet Sauvignon — 21 — (Cabernet Sauvignon)
27. Kadarka — 22 — (Kadarka noir)
28. Kéknyelű (H) — 23 —
29. Mézes (H) — 24 —
30. Bánáti rizling (H) — 25 —
31. Budai (H)
32. Piros szlanka — 26 — (Bois jaune, Pamidie)
33. Csomorika (H)
34. Pozsonyi (H)
35. Mustos (H)
36. Szerémi (H)
37. Erdei (H) — 27 —
38. Fehér szlanka = Magyarka (H)
39. Kövidinka (H)
40. Zöld dinka (H)
41. Izsáki (H) — 28 —
42. Muscadelle (Muscadelle de Bordelais)
43. Muscat Bouschet (Muscat Bouschet)
44. Kocsis Pál szilvánija (H)
45. Ortlibi — 29 — (Kniperle)
46. Aligoté (Aligoté blanc)
47. Gamay (Gamay noir, gris)
48. Burgundi fehér (Gamay blanc)
49. Vörös hegyű (Rotgifpler)
50. Merlot (Bigney, Merlan, Merlot noir)
51. Kövérszőlő (Grassa)
52. Királyleányka (H)
53. Neuburgi (Neuburger blanc)
54. Korai olasz (Früher Welscher)
55. Bajor = Bajnár (H)
56. Gohér (H) — 30 —
57. Bernáth János (H)
58. Kozma (H)
59. Gyöngyfehér (H)
60. Csókaszőlő (H)
61. Kecskemét virága (H)
62. Barátcsuha (Kölner noir)
63. Petit Bouschet (Aramon-Teinturier)
64. Szeredi (H)
65. Járdovány (H)
66. Juhfark (H) — 31 —
67. Királyszőlő (H)
68. Purcsin (Purchinok)
69. Sárfehér (H)
70. Szagos bajnár (H)
71. Hamvas = Barátcsuha (H)
72. Bálint (H)
73. Lisztes — 32 — (Fehér lisztes, piros l.; H)
74. Vékonyhéjú = Boros (H)
75. Olasz kadarka (?)
76. Aprófehér (H) — 33 —
77. Szegedi (H)
78. Mathiász muskotály (H)
79. Gyöngyszőlő (H)
80. Cigányszőlő (H) — 34 —
81. Alikánt Busé (Alicante Bouschet)
82. Alanttermő (H)
83. Beregi (H) — 35 —
84. Balafánt (Balafant blanc)
85. Vörös dinka (Dinka rouge)
86. Hosszúnyelű (H)
87. Mirkovácsa (Radovinka)
88. Bakator (Bakator, B. rouge)
89. Szemendriai
90. Pécsi dinka (H)
91. Rakszőlő (H)
92. Bogdányi (H)
93. Clairette (Clairette rose, blanche)
94. Aramon (Aramon noir, gris, rouge, blanc)

Table grape varieties

— Csiri-csuri — 36 — (Admirable de Courtiller)
— Dodrelabi — 37 — (Gros Colman)
— Tüskéspupú zamatos — 38 — (Puhljakovskij)
— Génuai zamatos — 39 — (Chaous)
— Afuz Ali — 40 —
— Ezeréves Magyarország emléke (H) — 41 —
— Cegléd szépe (H) — 42 —
— Kocsis Irma (H) — 43 —
— Mathiász Jánosné (H) — 44 —
— Chasselas blanc — 45 —
— Rosa menna di Vacca — 46 —
— Csaba gyöngye (H) — 47 —

(H) = Probably old Hungarian varieties, or such that was grown in Hungary.

The diagram of Fig. 11 in the first part of this study (Acta Botanica Acad. Sci. Hung. *22*, 209—247, 1976) has been compiled on the basis of the seed data of the 94 Vine grape varieties which have their serial number before their names.

The serial numbers to be found after the name of various varieties (1—47) mark those Vine grape varieties and table grapes varieties the data of which have also been used in several places of this study (for example, Acta Botanica Acad. Sci., Hung. *22*, 240—243). The data of the 47 species marked in this way were processed in our Institute.

Acta Botanica Academiae Scientiarum Hungaricae, Tomus 23 (1—2), pp. 275—283 (1977)

WOOD ANATOMY OF CERATOPYXIS HOOKER F. EX HOOKER (RUBIACEAE) A MONOTYPIC ENDEMIC GENUS OF WEST CUBA

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The anatomy of the secondary xylem of *Ceratopyxis verbenacea* (endemic in West Cuba) is described. Data of the vessel members, fibers, medullary rays and axial parenchyma are given, also some morphological and ecological characteristics.

Statistical methods were used in the processing and evaluation of the data to determine the variability of the vessel members and fiber length.

Introduction

The genus *Ceratopyxis* Hook. f. ex Hook., represented by the single species *Ceratopyxis verbenacea* (Griseb.) Hook. f. ex Hook belongs to the tribe *Chiococceae* of the family *Rubiaceae*. The plants are resiniferous unarmed tall shrubs or little trees up to 4—6 m heigth. Branches stout, thick and glabrous, with 5—10 mm long, coriaceous and persistent stipules, acuminate and mucronate at apex, connate at base. Leaves opposite, coriaceous, subsessile, blades oblong-elliptic or oblong-lanceolate, 4—10 cm long and 1—2.5 cm broad, shortly acuminate, at apex acute or obtuse; base cuneate; glabrous or puberulous at base. Inflorescences dense, many-flowered, terminal, 3—7 cm long thyrsoideous panicles with 4.5—14 cm long peduncles. Calyx 5-lobed, 4 mm long, sparsely puberulous, segments erect, rigid, lanceolate and subulate. Corolla yellowish, pale 5—lobed, 6—8 mm long, pilose externally, glabrous in the throat; segments valvate, lineo-lanceolate, reflexed. Stamens 5, inserted at base of corolla, filaments puberulous anthers dorsifixed, lineal, exserted. Ovary bilocular, style filiform, stigma bifide at apex. Ovules solitary, pendulous, cylindric. Capsule bilocular, coriaceous, loculicide, bivalvate, 4—5 mm long, puberulous. (Fig. 1.)

The genus is an endemic one of the limestone "haystack-hills" ("mogotes") of the Organos Range in West Cuba, with a very restricted area between Guane and San Diego de los Banos. (Fig. 2.) The ecological and cenological conditions of the species were studied by A. BORHIDI (1973. He found that this shrub is one of the most important elements in the pioneer phase of the succession of the haystackhills. In can be found sparsely in the fissures of the perpendicular, insolated slopes, in extreme microclimatic and water conditions; but it is frequent as a dominant species at the very tops of the mogotes, forming a very interesting endemic pioneer association with terrestrial *Bromeliaceae*, named by BORHIDI as *Vrieseo-Ceratopyxidetum*.

Fig. 1. Ceratopyxis verbenacea. Photo: A. BORHIDI
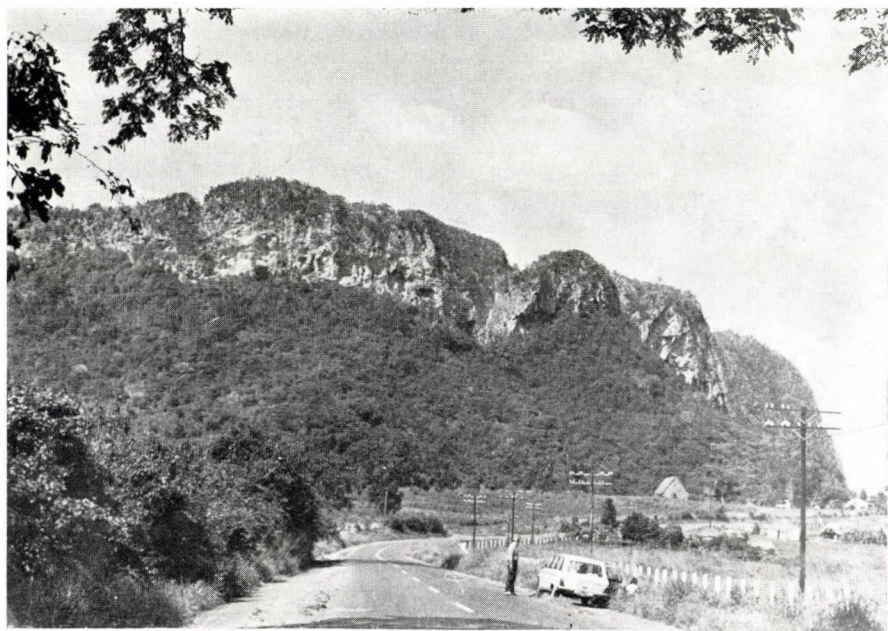
Fig. 2. Limestone haystack-hills in West Cuba. Photo: A. BORHIDI

Materials and Methods

For the study of the xylem elements, a wood sample of a mature trunk was collected, with its herbarium vouchers, in the upper most part of Jose Miguel's limestone haystackhill (Jose Miguel' Mogote), at the north end of the Viñales Valley, in the province of Pinar del Rio (see Table 1).

A wood block (1×1×2 cm in size) was aspirated under vacuum at room temperature until waterlogged, and then placed in an autoclave, with a 50% solution of glycerine in water, to a pressure of 3.5—4.5 atm during 1 1/2 hours.

Table 1

Citation of wood collection and location of Herbarium vouchers

Specific name	Collectors and date	Diam. of the wood sample	Serial Number of the wood in the collection	Place of collection	Location of Herbarium vouchers
Ceratopyxis verbenacea (Rubiaceae)	M. Vales, A. Borhidi 20—11—1974	6,8 cm	51	Jose Miguel's mogote Pinar del Rio, Cuba	Herbarium of the Academy of Sciences, Cuba

Sapwood white to pale yellowish, thickness about 17—19% or 0.5—0.7 cm.

Heartwood brownish, 2.4—2.6 cm from the pith to the sapwood, about 81—83%.

Heartwood in cross section with gummy contents, fibers curved when viewed in radial section.

For sectioning a Leitz sledge microtome was used. Cross (C. S.), longitudinal tangential (L. T. S.), and longitudinal radial sections (L. R. S.) were made to a thickness of 12 to 15 μ. The sections were stained in a 3% solution of Toluidin blue in 50% ethylic alcohol, differentiated, dehydrated, cleared in xylene and mounted in Canada balsam.

Lengths of the vessel members and fibers was measured in macerated material. For this purpose a small wood sample was heated in a 1 : 1 mixture of hydrogen peroxide and glacial acetic acid at 60 °C (Franklin, 1945). One hundred fibers were measured, while for the other features only 30 to 50 measurements were taken.

Frequency, mean and standard deviations for the length of the vessel members and fibers were calculated according to Sváb, 1967.

Number of vessels, fibers, medullary rays and axial parenchyma per sq. mm was obtained from the study of ten different areas in the cross section as viewed under a Carl Zeiss microprojector, and the mean was calculated.

The most frequent range (M. F. R.) was obtained when the frequency was more than 50% of the total.

For photomicrography, a Carl Zeiss microscope and an Exacta Varex IIb camera was used.

Microscopic Anatomy

Wood diffuse porous, growth rings absent. Pores very numerous, rounded to slightly oval, very small, predominantly solitary (Fig. 3). Mean length of vessel members 658.8 μ, M.F.R. 470— 891 μ. Middle tengential and radial diameters 37.7 μ and 42.5 μ, respectively. Cell walls 2.3—5.7 μ thick (Fig. 4). Intervascular pitting alternate and minute, borders roundish 3—4.2 μ in diam-
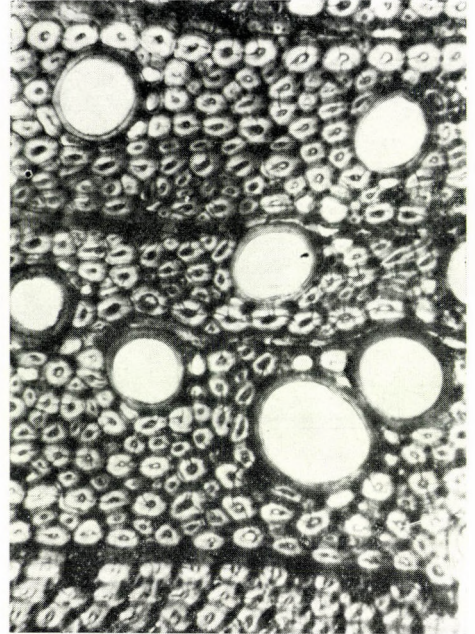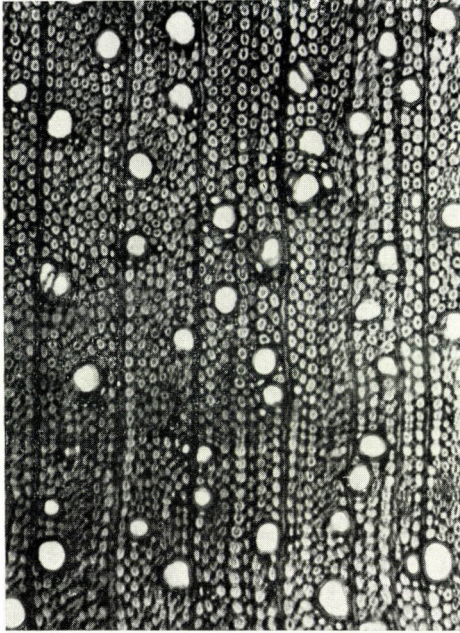
Fig. 3. Uniseriate medullary rays, scanty paratracheal wood parenchyma and walls of the fibers very thick. Cross section. Magnification: 120×

Fig. 4. Thick wall of the vessel members, wood parenchyma cells, canals of the bordered pits in the walls of the fibers. Cross section. Magnification: 300×
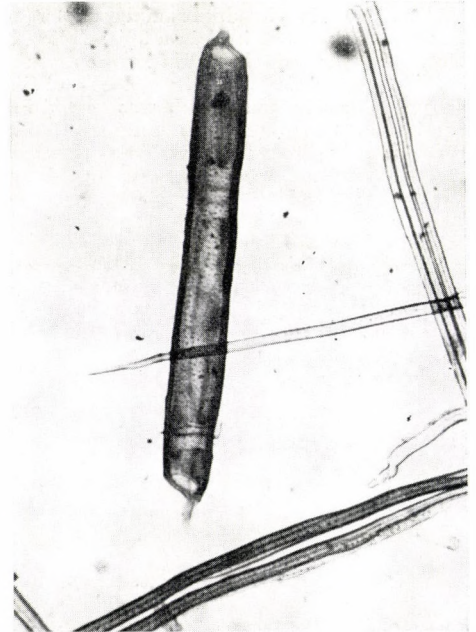
Fig. 5. Vessel members type I. with very large tails, fibers and wood parenchyma. Magnification: 120×

Fig. 6. Vessel members type II. with short tails, simple perforation plates and minute bordered pits. Magnification: 120×

eter, aperture also roundish 0.5—1.2 μ in diameter. Perforation plate simple Vessels in heartwood with gummy contents (Figs 5 and 6).

Medullary Rays. — Uniseriate, not very frequently 2 cells smaller in width in some rays (Fig. 7). Width very fine from 5.4—14 μ; height from 1 to 28 cells or 17.7—323.5 μ. Cells mostly procumbents (Fig. 8), sometimes upright cells in margin of rays. Cell walls 1.8—3.6 μ thick; pitted. Rays in heartwood with gummy content (Figs 9 and 10).
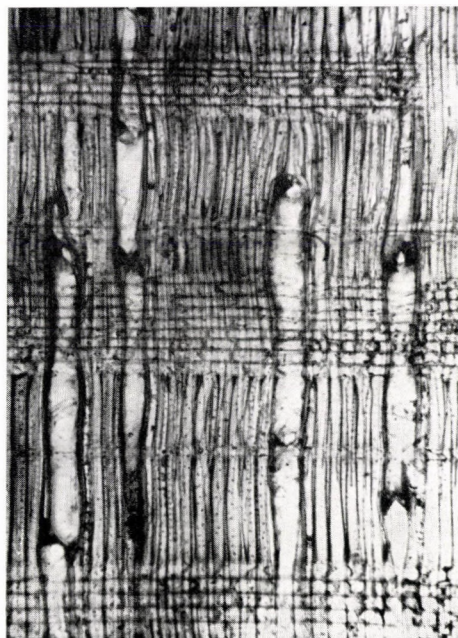
Fig. 7. Sapwood elements without gummy contents. Medullary rays with 2 small cells in width. Longitudinal tangential section. Magnification: 300×

Fig. 8. Gummy contents in vessel elements. Homogeneous medullary rays formed from procumbent cells. Longitudinal radial section. Magnification. 120×

Fibers. — Polygonal, radial distribution, with very small lumen (Figs 3 and 4). Mean length 934 μ, M.F.R. 740—1159. Middle diameter 17.2 μ. Walls commonly 2.7—9.8 μ thick. Pits small, distinctly bordered, and with slit-like aperture (Fig. 11). In cross section, canals of pit very conspicuous.

Wood parenchyma. — Typically scanty paratracheal (Figs 3 and 4). In strands of 2—4 or up to 6 cells. Mean height of cells about 129.5 μ. Middle diameter 13.1 μ. Thickness of wall 0.9—1.9 μ. Pits abundant (Fig. 12).
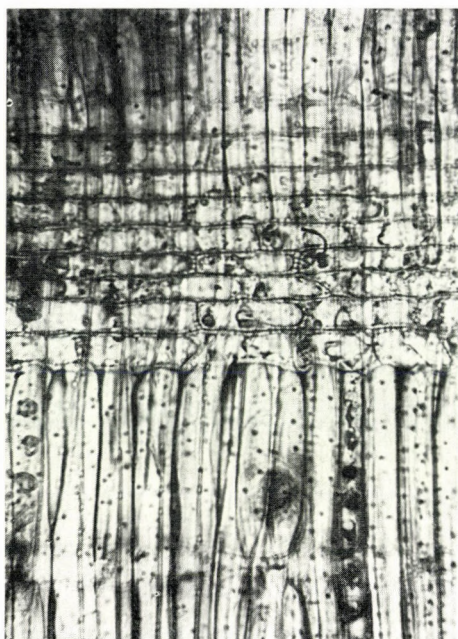
Fig. 9. Non-typical heterogeneous medullary rays. Minute bordered pits in the fibers. Longitudinal radial section. Magnification: 300×

Fig. 10. Heartwood vessel members, medullary rays and fiber lumen with gummy contents. Uniseriate medullary rays. Longitudinal tangential section. Magnification: 120×
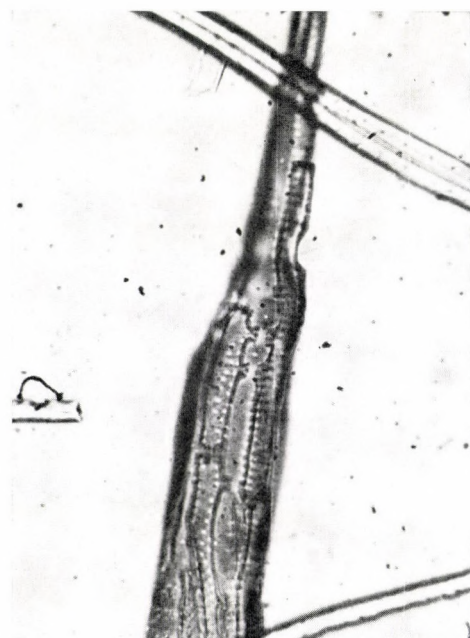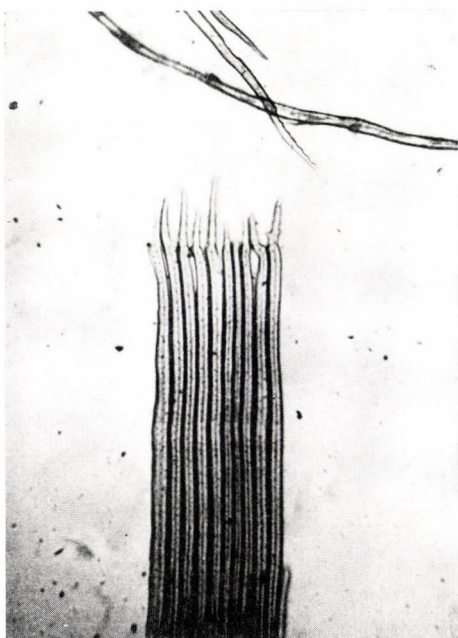
Fig. 11. Group of fibers with different ends and minute bordered pits. Magnification: 120×

Fig. 12. Interwood-parenchyma pitting. Magnification: 300×

Discussion

Only for the *Rubiaceae* family it was found literature in wood anatomy, and in any case these didn't treat about this genus.

Anatomical features of the xylem of *Ceratopyxis verbenacea* were compared with data recorded by METCALFE and CHALK (1950) for different genera of this family no significant differences (see Table 2) could be obtained from this comparison.

Table 3 shows data recorded from our wood anatomy research.

Lengths of the fibers and vessel members present a normal GAUSS distribution (Figs 13 and 14).

Classes and frequency for the vessel members and fiber lengths are given in Tables 4 and 5.
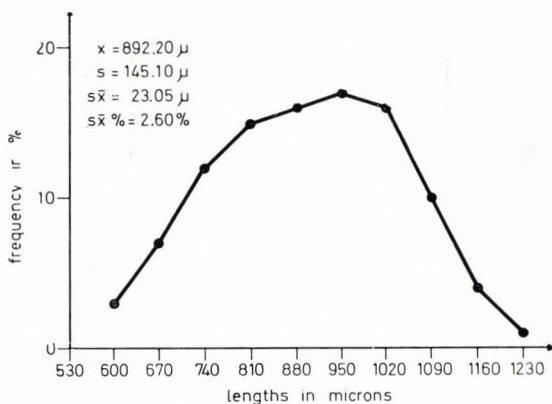
Fig. 13. Distribution of the fiber lengths of *Ceratopyxis verbenacea*
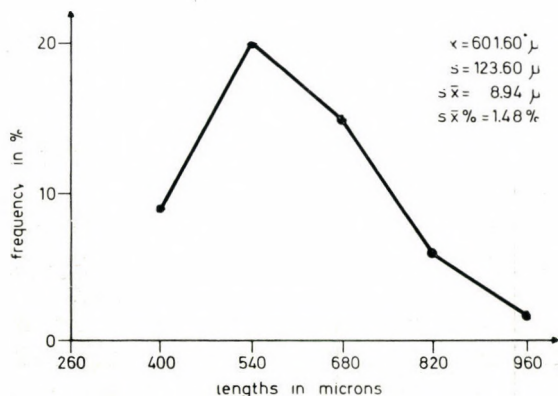
Fig. 14. Distribution of the vessel members lengths of *Ceratopyxis verbenacea*

Table 2

Comparative study of four data with one obtained by METCALFE *and* CHALK, *1950*

Wood elements	Anatomical features	Mean data for the family *Rubiaceae* according to METCALFE and CHALK, 1950	*Ceratopyxis verbenacea*
Vessels	Total length	500—1300 μ M.F.R. 500—800	414—1092.5 μ M.F.R. 470—819 μ
	Tang. diam.	very small, small, medium size	very small 20.7—52.5 μ
	Number per sq. mm	>50	84
	Perforation plate	simple	simple
	Pitting	alternate	alternate, minute
Axial parenchyma strands strands	Distribution	Apotracheal or vasicentric	scanty paratracheal
	number of cells	4—8	2—6
Medullary rays	Size	Uniseriate or 2 distinct sizes	uniseriate rarely 2 cells very small
Fibers	Total length	600—2.200 μ mostly 1100—1500 μ	609.5—1253.5 μ M.F.R. 740—1159 μ
		septate or not	not septate
	Pitting	Bordered or simple	Bordered minute

Table 3

Comparison of dimensions of the xylem elements of Ceratopyxis verbenacea
(Values expressed in microns)

Anatomical features	Vessels	Fibers	Axial Parenchyma	Medullary rays
Total length	414—658.9—1092.5	609.5—934—1253.5	—	—
Tang. diam.	20.7—37.7—52.9	7.2—17.2—25.2	3.6—13.3—19.8	
Rad. diam.	20.7—42.5—55.2 —			
Lumen	—	1.8—3.7—7.2	—	—
Number per sq. mm	84	3068	170	88
Thickness of wall	2.30—4.6—5.7	2.7—6.7—9.8	0.9—1.8	1.8—2.16—3.6
Distribution	Diffuse	Radial	Paratracheal	—
Pits	Bordered, minute alternate	Bordered, minute	Simple, of the same size	Simple, of the same size
Height of cells	—	—	74.5—129.5—230.7	12.6—13.6—25.2
Radial length	—	—	—	32.4—50.4—68.4
Height	—	—	—	17.7—108.6—323.5
Width	—	—	—	5.4—9.1—14.4

Table 4

Frequency of the member lengths of vessels

	Class in microns	Frequency	f/100	f %
0	400	9	0.09	9
1	540	20	0.20	20
2	680	15	0.15	15
3	820	6	0.06	6
4	960	1	0.01	1

Table 5

Frequency of the fiber lengths

	Class in microns	Frequency	f/100	f %
0	600	3	0.03	3
1	670	7	0.07	7
2	740	12	0.12	12
3	810	15	0.15	15
4	880	16	0.16	16
5	950	17	0.17	17
6	1020	15	0.15	15
7	1090	10	0.10	10
8	1160	4	0.04	4
9	1230	1	0.01	1

Concerning wood anatomy in relation to the phylogeny it might be stated that the secondary xylem of *Ceratopyxis* shows evidences of specialization. Vessel perforation plates are exclusively simple and intervascular pitting are bordered, alternate and minute, features which imply a very high specialization.

ACKNOWLEDGEMENT

We are indebted to Dr. A. BORHIDI for his great aim in the introductory part of this paper and for his personal help and to Mrs. BARBARD for her clerical work.

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ZUR NOMENKLATUR VON OPHRYS FUCIFLORA

Von

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(Eingegangen am 25. August, 1975)

This note attempts to provide a short survey of the history of *Ophrys* fuciflora auc. rec. and to clarify its nomenclatural situation. It was found that neither *Orchis fuciflora* Cr. nor *Orchis arachnites* Scop. and *Orchis holoserica* Burm. fil. can be used as basionyms. *Orchis fuciflora* Cr. has no reference to *Ophrys fuciflora* Moench and must therefore be excluded from further consideration. *Orchis arachnites* Scop. cannot be used because of the existence of *Ophrys adrachnites* Miller, a later synonym to *Ophrys apifera* Huds. *Orchis holoserica* Burm fil. is a doubtful synonym of *Ophrys apifera*, if not rejected as nomen confusum. The next available and legitimate name is *Arachnites fuciflora* F. W. Schmidt, on which MOENCH based his combination *Ophrys fuciflora*. It is therefore suggested to consider *Ophrys fuciflora* (F. W. Schmidt) Moench as the correct name under art 11 ICBN.

Die Nomenklatur von *Ophrys* (*O.*) *fuciflora* gehört zu den schwierigsten Problemen auf diesem Gebiet. Mehr als ein Jahrhundert standen die Namen *O. fuciflora* und *O. arachnites* miteinander in Wettbewerb, ohne daß sich jemand berufen fühlte, die Verhältnisse abschließend zu klären. Schließlich setzte sich *O. fuciflora* durch, wobei aber weiterhin umstritten blieb, welche Autoren für diese Kombination zu zitieren waren. 1967 kam GREUTER nach einer eingehenden Prüfung der einschlägigen Textstellen zu dem Ergebnis, daß auch *O. fuciflora* zu verwerfen sei. Statt dessen schlug GREUTER vor, für *O. fuciflora* den Namen *O. holosericea* (Burm. fil) Greuter zu verwenden. SUNDERMANN nahm auf dieser Grundlage weitere Kombinationen vor. Die Begründetheit dieser Neuerungen ist jedoch zweifelhaft. Es erscheint daher angebracht, einmal nachvollziehbar die komplizierte Nomenklaturgeschichte der *O. fuciflora* darzulegen und an den Bestimmungen des Internationalen Codex der botanischen Nomenklatur (ICBN) zu messen.

I

1. Als erster, nach den Nomenklaturregeln erheblicher Name für *O. fuciflora* und damit als Ausgangspunkt ihrer Nomenklaturgeschichte gilt Carl von LINNES *O. insectifera* var. *adrachnites* oder *arachnites* 1753. Allerdings beginnen bereits hier die Auslegungsschwierigkeiten. LINNE begründete diesen Namen auf dem Zitat vier älterer Synonyme, die unterschiedliche Deutungen

erlauben. Legt man das Hauptgewicht auf das Zitat von Sebastien VAILLANT, dessen Abbildungen LINNE noch weiteren Varietäten zugrunde legte, dann kann dieser Name durchaus auf *O. fuciflora* bezogen werden. LINNE selbst brachte jedoch wenige Jahre später seine var. *arachnites* mit *O. sphegodes* (in Amoenitates Acad. IV 1759, S. 107) in Verbindung. Schließlich (ab 1771) schloß sich LINNE in vollem Umfang HALLER an, der mindestens *O. fuciflora* und *O. apifera* zusammenfaßte, was anschließend darzulegen sein wird.

2. Albrecht von HALLER veröffentlichte 1760 unter dem Titel »Orchidum Classis constituta« einen Aufsatz, der für die Systematik der europäischen Orchideen im 18. und frühen 19. Jahrhundert grundlegend wurde. Als Nr. 5 führte er eine Art auf, die er nach vorlinneischer Tradition als *Orchis radicibus subrotundis, labello holosericeo, emarginato, medio processu brevissimo* bezeichnete und deren Beschreibung auf *O. fuciflora* weist. Jedoch bezog HALLER auch *O. apifera* und sogar *O. sphegodes* mit ein. HALLER war nämlich der Ansicht, daß *O. sphegodes*, besonders aber *O. apifera* Abblühformen von *O. fuciflora* seien. Vor allem die kennzeichnenden Merkmale der *O. apifera* (dreilappiges Labellum, verlängerter Konnektivfortsatz, zurückgeschlagene Sepalen usw.) faßte HALLER als Veränderungen bei der Alterung der *O. fuciflora*-Blüte auf.

3. In seinem 1768 erschienenen Werk »Historia stirpium indigenarum Helvetiae etc« bekräftigte HALLER seine Auffassung. Er änderte den ursprünglichen Namen ab in Nr. 1266 *Orchis radicibus subrotundis, labello holosericeo, emarginato, appendiculato*, bezeichnete die Abblühformen (also *O. apifera* und *O. sphegodes*) als Varietät ß und bildete (Tafel 24) *O. fuciflora*, sowie zwei Einzelblüten von *O. apifera* hervorragend unter der Bezeichnung »Orchis fuciflora« ab. Die überragende Autorität HALLER's hatte zur Folge, daß sich im kontinentaleuropäischen Schrifttum erst im 19. Jahrhundert die Überzeugung durchsetzte, daß nicht nur zwei, sondern vier Ophrysarten nördlich der Alpen vorkommen. Selbst LINNE konnte sich dem Einfluß HALLERS nicht entziehen. Er übernahm (in Mantissa altera 1771) den polynominalen Artnamen von HALLER 1768 als Diagnose für die von ihm begründete var. *arachnites*. So verbanden sich LINNES *Ophrys insectifera* var. *arachnites* und HALLERS Orchis Nr. 1266 und wurden Grundlage der Nomenklatur von *O. fuciflora*.

4. Ein anderer Name für *O. fuciflora* ist *Orchis fuciflora* Crantz 1769. Obwohl an LINNE und HALLER anknüpfend, zog J. Heinrich Nepomuk CRANTZ die Artgrenzen enger und beschränkte seine *Orchis fuciflora* eindeutig auf *O. fuciflora* im heutigen Sinn. Bereits in seiner, der eigentlichen Beschreibung vorausgehenden Kurzdiagnose kennzeichnete er seine *Orchis fuciflora* zweifelsfrei durch den Hinweis auf das ungeteilte Labellum und nach vorn gebogene Labellanhängsel.

5. Ebenfalls auf *O. fuciflora* bezieht sich nach GREUTER *Orchis holoserica* Burm. fil. 1770. Eine befriedigende Zuordnung dieses Namens ist jedoch schwierig, da er lediglich auf dem Zitat zweier älterer Synonyme begründet

wurde und das Typusexemplar, eine korsische Pflanze, verschollen ist. Das erste Synonym ist HALLER Orch. Nr. 5. Wie bereits dargelegt, steht bei HALLER zwar *O. fuciflora* im Vordergrund, *O. apifera* und auch *O. sphegodes* können jedoch nicht ausgeschlossen werden. Das zweite Synonym ist Caspar BAUHIN Pinax S. 83 Nr. VII *Orchis fucum referens major foliolis superioribus candidis et purpurascentibus.* Auch hier handelt es sich um einen sehr schwierig zu deutenden Namen. BAUHIN gab keine Diagnose, sondern gründete ihn auf 16 Synonymen des 16. und frühen 17. Jahrhunderts. Der in dem Namen enthaltene Hinweis auf die Größe der Pflanzen deutet auf *O. apifera* hin. In diesem Sinne ist auch der Name BAUHINS mehrheitlich ausgelegt worden. Die Tradition geht im wesentlichen auf Sebastien VAILLANT 1727 zurück, der wohl erstmals alle vier nördlich der Alpen vorkommenden Ophrysarten nebeneinander und zweifelsfrei abbildete und den verschiedenen Namen C. BAUHINS zuordnete. *O. sphegodes* wird als *Orchis fucum referens colore rubiginoso* C. Bauhin Pinax 83, *O. fuciflora* als *Orchis araneam referens* C. Bauhin Pinax 84 and *O. apifera* als *Orchis fucum referens, galea & alis purpurascentibus* Vaill. auf der Abbildung bezeichnet, sowie im Text (S. 146/47) von VAILLANT auf BAUHINS *Orchis* Nr. VII Pinax 83 bezogen. LINNE z. B. ist VAILLANT in Species Plantarum 1753 in vollem Umfange gefolgt. Auch Jean Francois SEGUIER 1754, der erstmalig *O. fuciflora* und *O. apifera* einander kritisch gegenüberstellte, folgte VAILLANT und bezeichnete *O. fuciflora* als *Orchis araneam referens* C. B. Pinax 84. Für *O. apifera* bildete er den neuen, bezeichnenden Namen *Orchis araneam referens rostro recurvo,* da er in einem früheren Werk (1745) BAUHINS Orchis Nr. VII wie alle *Orchis fucum referens*-Namen BAUHINS auf *O. sphegodes* bezogen hatte. Dieses Beispiel zeigt, mit welchen Unsicherheiten die Zuordnung der BAUHINschen Namen belastet ist. BAUHINS *Orchis* Nr. VII wurde auch unabhängig von VAILLANT als *O. apifera* gedeutet. Z. B. in der von Johann Jakob DILLENIUS bearbeiteten 3. Auflage von John RAYS »Synopsis Methodica Stirpium Britannicarum« 1724, einem der bedeutendsten botanischen Werke des 18. Jahrhunderts vor LINNE, wird *O. apifera* als *Orchis fuciflora, galea & alis purpurascentibus* Johann Bauhin, 2, 766 bezeichnet und Caspar BAUHINS *Orchis* Nr. VII als Synonym aufgeführt. Einzuräumen ist allerdings, daß HALLER *Orchis* Nr. VII C. B. mit der Abbildung von *O. fuciflora* bei VAILLANT in Verbindung brachte. Da HALLER aber VAILLANTS Abbildung der *O. apifera* ebenfalls zitierte, und zwar bei der »Abblühform« (und späteren var. ß) läßt sich dies zwanglos durch die von HALLER angewandte Artumgrenzung erklären. Unterstellt man, daß BURMANN das Zitat BAUHINS nicht einfach von HALLER übernommen hat, sondern im Sinne seiner Zeitgenossen auslegte, spricht vieles dafür, daß sich *Orchis holoserica* Burm. fil. auf *O. apifera* beziehen sollte. Hinzu kommt, daß *O. fuciflora* sensu stricto bisher nicht mit Sicherheit für Korsika nachgewiesen wurde. Nach BRIQUET kommen auf Korsika nur u. a. *O. exaltata, O. scolopax* und *O. apifera* vor. BRIQUET betrachtete *Orchis holoserica*

als Synonym von *O. apifera* und ein beachtlicher Teil des Schrifttums folgte ihm darin (vgl. CAMUS, Ic. Orch. S. 322, NELSON S. 175, KELLER—SOÓ S. 67).

6. Als auf *O. fuciflora* zu beziehender Name gilt ferner *Orchis arachnites* Scopoli 1772. Dies trifft allerdings nur sehr bedingt zu. Wohl zitierte SCOPOLI Orchis Nr. 1266 von HALLER 1768 und bezeichnete das Labellum als ungeteilt. Er spaltete jedoch seine *Orchis arachnites* in drei Varietäten auf, wovon die erste nach den zitierten Abbildungen und der Diagnose mit Sicherheit *O. apifera* und die dritte *O. sphegodes* ist. Lediglich die zweite Varietät könnte für *O. fuciflora* in Anspruch genommen werden. SCOPOLI folgte demnach in vollem Umfang HALLER.

7. Gleiches dürfte auch für Johann Jakob REICHARD gelten, der erstmals um 1772 die Kombination *Ophrys arachnites* vornahm. Aus der Textstelle geht die Umgrenzung der Art durch REICHARD nicht hervor. Zitiert werden sowohl HALLER, LINNE und SCOPOLI. Da sich aber im Herbar von REICHARD unter der Bezeichnung *O. arachnites* ein Exemplar von *O. apifera* befand (nach DÖLL Fl. Baden, zitiert nach ASCHERSON und GRAEBNER S. 630) sind unter diesem Namen zumindest *O. fuciflora* und *O. apifera* zusammengefaßt worden.

8. Bekannter und später häufiger zitiert wurde allerdings die Kombination *O. arachnites* Lamarck 1778. Jean Baptiste de LAMARCK bezog sich auf HALLER, auch auf VAILLANT und dessen Abbildungen von *O. fuciflora*, die beigegebene Beschreibung betrifft jedoch ausschließlich *O. apifera*. Auch *O. sphegodes* ist mit eingeschlossen.

9. Die für die Nomenklaturgeschichte bedeutsamste Kombination *O. arachnites* erfolgte jedoch erst 1784 durch Johan Anders MURRAY. LINNE hatte sich nie entschließen können, seine Sammelart *O. insectifera* aufzugliedern. Erst in der 14. Auflage von LINNES »Systema Vegetabilium« erhob der Bearbeiter dieser Auflage, MURRAY. *O. insectifera* var. *arachnites* L. in den Rang einer Art. Er versah sie mit einer Beschreibung, die HALLERS Phrase von 1768 und damit LINNES Diagnose nur unwesentlich abwandelte und zitierte HALLERS Abbildung. Hieraus darf geschlossen werden, daß *O. arachnites* (L.) Murr. sowohl *O. fuciflora* als auch *O. apifera* umfaßte. Diese Kombination erlangte deshalb entscheidende Bedeutung, weil sie das spätere Schrifttum mit der Autorität LINNES verband. Vielfach wurde sogar LINNE als Autor genannt. Fast alle späteren Kombinationen im Zusammenhang mit *O. fuciflora* hängen von diesem Namen ab.

10. Dies gilt auch für den von Franz von Paula SCHRANK 1789 geprägten Namen *Orchis fuciflora*. Die Diagnose der *Orchis fuciflora* Schrank ist eine deutsche Übersetzung der Beschreibung MURRAYS. Außerdem wird die Abbildung HALLERS zitiert, wovon SCHRANK offensichtlich seinen Namen übernahm. Auch diese Kombination ist daher auf *O. fuciflora* und *O. apifera* zu beziehen.

11. Eine Neukombination von *O. arachnites* Murray ist auch *Epipactis arachnites* F. W. Schmidt 1791, allerdings mit einer bemerkenswerten Einschränkung. In der Diagnose bezeichnete Franz Willibald SCHMIDT das Labellum ausdrücklich als »ungeteilt, ausgerandet und fast dreilappig«. Damit wird erstmals wieder seit CRANTZ 1769 eindeutig ein Name gebildet, der sich ausschließlich auf *O. fuciflora* beziehen dürfte.

12. Zwei Jahre später, 1793, überführte SCHMIDT seine *Epipactis arachnites* in die von ihm neugeschaffene Gattung *Arachnites.* Um das Entstehen eines Tautonyms zu vermeiden, benannte SCHMIDT sie nunmehr in *Arachnites fuciflora* um. Nach den angegebenen Synonymen zu urteilen, entlehnte SCHMIDT das Epitheton »fuciflora« von SCHRANK. CRANTZ war SCHMIDT zwar bekannt und er zitierte ihn an anderer Stelle ausführlich, nicht jedoch bei *Arachnites fuciflora.* In der Textstelle erwähnte SCHMIDT außerdem das für *O. fuciflora* kennzeichnende Haarbüschel über dem Labellanhängsel und grenzte seine *Arachnites fuciflora* damit auch zweifelsfrei gegenüber *O. sphegodes* ab.

13. Im Jahre 1800 tauchte erstmals die Kombination *Ophrys fuciflora* auf. Olof SWARTZ gab eine Aufzählung der zu *Ophrys* gehörenden Arten. Dabei erwähnte er *O. fuciflora,* aber auch *O. arachnites.* Alle diese Namen sind jedoch ohne Beschreibung oder Angabe von Synonymen. Ihr Inhalt ist daher nicht erfaßbar. Allerdings wurde *O. fuciflora* Sw. später häufig als gültiger Name zitiert, jedoch könnte dieser Name mit gleichem Recht für andere Taxa in Anspruch genommen werden, wie LAMARCK 1805 dies tat, als er *O. fuciflora* Sw. auf *O. sphegodes* bezog und als var. ß seiner *O. arachnites* zitierte.

14. Schließlich, 1802, bildete Konrad MOENCH seine Kombination *Ophrys fuciflora,* auf *Arachnites fuciflora* Schmidt fußend. Aus der Diagnose MOENCHs ergibt sich mit Eindeutigkeit, daß er damit *O. fuciflora* im heutigen Sinne kennzeichnete. Das Labellum wird als sehr breit und schwach dreilappig bezeichnet, womit offenbar die zuweilen fast trapezförmige Lippe der *O. fuciflora* angesprochen wird.

II

1. Nach Art. 11 Absatz 3 IBCN ist der korrekte Name einer Art die Kombination des ältesten zur Verfügung stehenden Epithetons auf derselben Rangstufe mit dem korrekten Namen der Gattung, der die Art zugeordnet ist. Da die Bezeichnung »*Orchis fuciflora*« bei HALLER 1768 nur ein Kürzel für den polynominalen Namen *Orchis* Nr. 1266 ist und HALLER sich nie zu einer Übernahme des linneischen Nomenklatursystems entschließen konnte, ist dieser »Name« nach Art 23 Anm. 3 ICBN unbeachtlich. Es handelt sich um eine Bezeichnung, die nur zufällig den Erfordernissen der modernen Be-

nennungsweise entspricht (sog. pseudobinärer Name). *Orchis fuciflora* Cr. ist damit der älteste Artname und demgemäß ist das Epitheton »fuciflora« bei Bildung des korrekten Namens grundsätzlich zu verwenden (sog. Basionym). *O. fuciflora* Moench ist die älteste gültige Kombination des Epitheton »fuciflora« unter die korrekte Gattungsbezeichnung *Ophrys*, denn der Name von SWARTZ 1800 enthält weder eine Diagnose noch eine individualisierende Bezugnahme auf Synonyme. Er widerspricht somit den zwingenden Formvorschriften der Art. 32 ff ICBN und ist folglich unwirksam (sog. nomen invalidum) und nach den Nomenklaturregeln unbeachtlich. (Art. 12 ICBN). Jedoch setzt Art. 11 Abs. 3 ICBN nach Sinn und Wortlaut voraus, daß das älteste zur Verfügung stehende Epitheton und nur dieses, nicht ein anderes, zufällig gleichlautendes tatsächlich kombiniert wird. Zwischen *Orchis fuciflora* Cr. und *Ophrys fuciflora* Moench bestehen aber keine derartigen Beziehungen. *O. fuciflora* Moench ist eine Neukombination von *Arachnites fuciflora* Schmidt. Dieser Name wiederum ist ein Ersatzname (nomen novum) für *Epipactis arachnites*, der auf der Kombination *O. arachnites* Murr. beruhte, welche durch Rangerhöhung von *O. insectifera* var. *arachnites* L. entstand. Auch *Orchis fuciflora* Schrank, wovon SCHMIDT das Epitheton für seine *Arachnites fuciflora* entlehnte, steht in keiner erkennbaren Beziehung zu CRANTZ. GREUTER ist daher zuzustimmen, daß es die Kombination »*O. fuciflora* (Crantz) Moench« nicht gibt.

2. Eine Nachholung der Neukombination von *Orchis fuciflora* Cr. unter *Ophrys* verbieten die Nomenklaturregeln. Nach Art. 64 ICBN sind Namen oder Kombinationen unzulässig, sofern sie mit einem älteren, legitimen oder illegitimen Namen oder Kombination übereinstimmen (sog. heterotypische Homonyme). Die bereits bestehende Kombination *O. fuciflora* Moench verhindert daher eine Überführung des von CRANTZ geschaffenen Epithetons »*fuciflora*« auf *Ophrys*. Hierbei wird unterstellt, daß *Orchis fuciflora* Cr. und *O. arachnites* Murr., wovon sich *O. fuciflora* Moench ableitet, unterschiedliche Typen zugrundeliegen.

3. Die Kombination »*O. fuciflora* (Crantz) Moench« kann auch nicht unter Berufung auf Anmerkung 2 zu Art. 33 ICBN gültig gemacht werden. Diese Bestimmung erlaubt lediglich, über einen Formfehler bei Vornahme einer Neukombination hinwegzugehen, der in einem Irrtum bibliographischer Natur besteht. Es ist jedoch nicht Zweck dieser Regel, einen nach anderen Bestimmungen (wie hier z. B. Art. 11) fehlerhaften Namen zu rechtfertigen.

4. Da *Orchis fuciflora* Cr. wegen Art 64 ICBN nicht mehr als Basionym einer Neukombination unter *Ophrys* verwandt werden darf, ist nach Art. 72 ICBN auf das nun folgende »älteste verfügbare legitime, auf der betreffenden Rangstufe stehende Epitheton« zurückzugreifen. Nach GREUTER ist der nächstgültige Name für *O. fuciflora* BURMANNS *Orchis holoserica*. Er bildete daher die Neukombination *O. holosericea* (Burm. fil.) Greuter. Es ist jedoch

nicht eindeutig zu ermitteln, was BURMANN unter seinem Namen verstand. Will man ihn nicht von vornherein als undeutbar zurückweisen und unterstellt man, BURMANN habe sich bei dem Zitat BAUHINs der Auslegung wichtiger Autoren seiner Zeit angeschlossen, dann spricht alle Wahrscheinlichkeit dafür, daß es sich um ein jüngeres Synonym von *O. apifera* handelt. Nach Art. 55 ICBN bestimmt sich der Inhalt einer Neukombination nach dem Basionym bzw. dem ihm zugrundeliegenden Typus. Geht man also davon aus, daß *Orchis holoserica* der *O. apifera* entspricht, muß *O. holosericea* (Burm fil.) Greuter als Synonym von *O. apifera* bewertet werden. Dieser Name scheidet also für die Nomenklatur von *O. fuciflora* aus.

5. Der nächste zur Verfügung stehende Name wäre *Orchis arachnites* Scop. Aber abgesehen davon, daß es sich hier um eine Sammelart handelt, die *O. fuciflora* nur neben anderen Arten enthält, ergäbe eine auf dieses Basionym begründete Neukombination unter *Ophrys* nur ein illegitimes Homonym. Im Jahre 1768 hatte nämlich Philip MILLER den Namen *O. adrachnites* als jüngeres Synonym von *O. apifera* gebildet. »*Adrachnites*« ist aber nur eine Schreibvariante zu »*arachnites*«. LINNE z. B. gebrauchte 1753 beide Schreibweisen nebeneinander in der gleichen Textstelle. *O. arachnites* Reichard ist daher ein jüngeres und damit illegitimes Homonym zu *O. adrachnites* Miller. Somit scheidet diese Kombination sowie alle anderen, späteren *arachnites*-Kombinationen für eine weitere Betrachtung aus.

6. Gleiches gilt für *Orchis fuciflora* Schrank, und zwar aus einem doppelten Grund. Einmal ist dieser Name ein jüngeres Homonym zu *Orchis fuciflora* Crantz und fällt schon von daher als Basionym aus, da nach Art 55 ICBN nur legitime Namen Grundlage einer Neukombination sein dürfen. Zum anderen würde durch die Überführung des Epithetons in die Gattung *Ophrys* wiederum ein weiteres jüngeres Homonym zu *O. fuciflora* Moench entstehen.

7. Nomenklatorisch von Bedeutung ist erst wieder *Arachnites fuciflora* Schmidt. Grundlage dieses Namens ist *O. arachnites* Murr. Dieser Name ist illegitim, da er ebenfalls ein jüngeres Homonym zu *O. adrachnites* Miller darstellt. Damit ist auch die hierauf begründete Kombination *Epipactis arachnites* Schmidt illegitim, die durch *Arachnites fuciflora* Schmidt ersetzt wurde. Trotz dieser Ableitung erweist sich jedoch *Arachnites fuciflora* selbst nach den Nomenklaturregeln als legitim. Es handelt sich nämlich hierbei um einen sog. Ersatznamen (nomen novum) im Sinne von Art 7 Anm. 11, Art. 72 ICBN. SCHMIDT wollte die Bildung des (illegitimen) Tautonyms »*Arachnites arachnites*« vermeiden und schuf daher einen neuen Namen. Dieser Name begründete gemäß Art. 72 ICBN eine neue Priorität und ist gültig und legitim. Auch die Tatsache, daß SCHMIDT das Epitheton »fuciflora« einem illegitimen Namen (*Orchis fuciflora* Schrank) entlehnte, schadet nicht. Nach der Anmerkung zu Art. 72 ICBN kann nämlich ein Epitheton aufgenommen werden, welches dem Taxon vorher in einem illegitimen Namen gegeben

worden ist, falls sich nicht seine Anwendung in der neuen Stellung oder neuen Auffassung verbietet. Der nächste verfügbare Name nach *Orchis fuciflora* Cr. ist folglich *Arachnites fuciflora* Schmidt.

8. *Ophrys fuciflora* Moench ist eine Neukombination von *Arachnites fuciflora* und damit die erste legitime Kombination unter *Ophrys* im Sinne von Art. 11 ICBN. Basionym für diese Kombination ist also nicht *Orchis fuciflora* Cr., sondern das zufällig gleichlautende Epitheton von *Arachnites fuciflora* Schmidt, so daß der korrekte Name gemäß Art. 11 ICBN *Ophrys fuciflora* (F. W. Schmidt) Moench lautet.

Das Ergebnis der nomenklatorischen Überprüfung ist sicher auf den ersten Blick verblüffend, nach den Nomenklaturregeln aber folgerichtig. Die Tatsache, daß einerseits der älteste Artname *Orchis fuciflora* Cr. nicht benutzt werden kann, daß aber andererseits doch *O. fuciflora* Moench der korrekte Name ist, ist die Folge des Zufalls, daß das Epitheton »fuciflora« mehrfach und unabhängig von einander zur Kennzeichnung des gleichen Taxons gebraucht wurde (wahrscheinlich abgeleitet von dem vorlinneischen Namen *Orchis fuciflora, galea & alis purpurascentibus* J. Bauhin). Zusammenfassend ist festzustellen, daß es eine Kombination »*O. fuciflora* (Crantz) Moench« nicht gibt, weil *O. fuciflora* Moench nicht auf *Orchis fuciflora* Cr. zurückgeführt werden kann. Die Kombinationen *O. arachnites* (Scop) Reichard und *O. arachnites* Lam. sind als jüngere Homonyme von *O. adrachnites* Miller illegitim. *O. holosericea* (Burm fil) Greuter scheidet aus, weil sein Basionym entweder als nicht deutbar zu verwerfen oder wahrscheinlich ein Synonym zu *O. apifera* ist. *O. fuciflora* Sw. ist ein ungültiger Name. Auch die oft zitierte Kombination *O. fuciflora* Reichenbach pat. ist illegitim, da sie ein jüngeres Homonym zu *O. fuciflora* Moench darstellt. Es bleibt als einzige gültige und legitime Kombination *O. fuciflora* (F. W. Schmidt) Moench, da sie auf dem nach *Orchis fuciflora* Cr. nächstverfügbaren legitimen Namen *Arachnites fuciflora* Schmidt beruht.

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RECENSIONES

Hybridization and the Flora of the British Isles. Edited by C. A. STACE. Academic Press, London, New York, San Francisco 1975. pp. 626. £ 14.80.

This book is very remarkable in four aspects.

1. It demonstrates the highly advanced state of floristic studies in British Isles. While in some countries botanists are tackling to produce the first species list of flowering plants, Britain was able to make a compilation of 1439 interspecific vascular plant hybrids.

2. An evaluation of the occurrence of interspecific hybrids in the British Isles (see also C. A. STACE: Wild hybrids in the British Flora. In: S. M. WALTERS edit.: European Floristic and Taxonomic Studies. Published for the Bot. Soc. Brit. Isl. by E. W. CLASSEY Ltd. 1975. p. 111—126) indicates, that out of some 2500 wild species there are 626 confirmed plus 122 possibly correct interspecific hybrids. In addition, 464 other combinations are listed which are known from other countries only although their parents grow in Britain. Thus, hybridization between different species is fairly common in nature.

3. Under each hybrid combination there are valuable informations as follows:

a) The valid binomial and the synonyms of the hybrid;
b) Description of the hybrid (morphology, fertility, variation, introgression, vigour, etc).;
c) Ecological and geographical distribution (both within and outside of the British Isles);
d) Survey of experimental work (e.g. artificial hybridization, back crossing, cytogenetic studies);
e) Chromosome number of the hybrid and its parents;
f) Reference to the most important literature.

4. The first part of the book (Section A. Introductory) contains an up to date review on hybrids and hybridization in general. This part is written by C. A. STACE, and it makes up almost one sixth of the book (90 pages). The treatment is very good and detailed, dealing with almost every aspects of hybridization (even the somatic cell hybridization is included).

Such book can never be complete since hybridization may occur in newer combinations and some less conspicuous ones are to be detected. Among these I mention the pentaploid *Cystopteris fragilis* which has also been found in Britain (VIDA, Acta Bot. Acad. Sci. Hung. 20: 182). On the other hand some obviously incorrect combinations (e.g. *Polypodium* × *Pteridium; Polypodium* × *Polystichum*) may well have been omitted.

Britain's Hybrid Flora is a very valuable book not only for British botanist but for all biologists too.

G. VIDA

Conservation of threatened plants. Edited by J. B. SIMMONS, R. I. BEYER, P. E. BRANDHAM, G. LL. LUCAS and V. T. H. PARRY. New York—London 1976. Plenum Press. XIV + 336 pp.

This is the first volume of the NATO Conference Series I: Ecology, and it embodies the proceedings of the "Conference on the Function of Living Plant Collections in Conservation and Conservation-orientated Research and Public Education, held at the Royal Botanic Gardens, Kew, England, September 2—6, 1975". Approximately 150 participants of twenty-eight

countries attended the work of this conference. Delegates were present from the German Democratic Republic, Yugoslavia, and also Poland, but South American countries, as well as China, India, and Japan, e.g., were not represented.

The main topics of the conference were; the resource potential of existing living collections; record systems; problems and techniques of cultivation; functions of conservation-orientated living plant collections in research; botanic gardens in relation to public education; international co-operation and legislation, etc. Instead of taking a detailed survey of all of the papers presented at the ten conference sections and published in this volume, the reviewer would like to draw the reader's attention to some cardinal problems discussed by the speakers and the audience.

It is a well-known fact that the world flora is seriously endangered by the growth of human populations and the demands of consumer societies. According to J. HESLOP-HARRISON (Kew, England), one tenth of the angiosperm species are threatened by extinction. P. H. RAVEN (Missouri Botanical Garden) underlined that "... the extinction of each species of plants is accompanied by a ten- to thirty-fold loss amongst other organisms" (p. 155). The number of threatened tropical plant species is extremely high; about one-third will be extinct by the end of this century. He stressed that introduced animals have often caused rapid and irreversible changes in species composition. For example, in Hawaii, at high elevations, "... grazing animals have very serious effects and it seems absolutely incomprehensible that authorities have thus far refused to exterminate the mammal populations, apparently considering the sport that hunting them provides to a few more important than the destruction and irretrievable loss of thousands of species of unique plants and animals which evolved in the Hawaiian island over millions of years" (p. 168).

Many economic reasons urge a policy of conservation for plants, because in the long run our own survival depends on a wise and balanced exploitation of the vegetation. Most of the conference participants agreed that such policies must be based primarily on conservation in the natural habitat and that "... the basic requirement for the preservation of the threatened floras of the world is ... the setting up of an adequate network of ecosystem reserves in all the major floristic regions" (J. B. SIMMONS, Kew, England). Living plant collections and botanic gardens are not able to replace the conservation in the field, but they certainly will meet their obligations in the integrated system of conservation of endangered plant species and ecosystems and in their restoration and re-establishment (p. 13, G. BUDOWSKI, IUCN, Switzerland; p. 27, J. B. SIMMONS).

K. ESSER (Bochum, FGR) and other contributors have made a clear distinction between preservation and conservation of threatened populations and species. Conservation means to keep populations under the same conditions as in nature, following the same paths of evolution. Preservation denotes to keep them essentially in the same state as when they were taken from the natural habitat. In cultivated collections neither of these aims is attainable for different reasons (e.g. continuous alteration of genotypes by genetical recombination; unwanted hybridization; selection by incompletely controllable environment, etc., (pp. 185—186) O. H. FRANKEL (Canberra City, Australia), G. HAWKES (Birmingham, England), K. ESSER and others urged the great importance of proper sampling methods by the creation of living collections. Every effort has to be made in order to reduce sampling errors and to get samples containing the majority of the genotypic variants of the whole native population sampled. From this point of view, V. H. HEYWOOD (Reading, England) was wholly right when he criticized very sharply the usual practice of most botanic gardens to get seed samples from other gardens and to offer them for exchange through seed lists, which "... tended in many cases to become overlarge, unselective, inaccurate and repetitious in the sense that they contained the same material often received shortly before from other gardens ... A more or less standard set of taxa was built up in many botanic gardens often at the expense of local native taxa which were largely ignored. The seed lists reflected this and the same often inaccurately identified seeds were exchanged, cultivated, exchanged, and cultivated, year after year ... The consequence: considerable percentage of taxonomic misidentification of plants grown in botanic gardens ..." (p. 227). His recommendation is: "... seed exchange should become a much more critical and selective activity ... The number of taxa listed will have to be reduced, allowing gardens to concentrate on their native floras, specialized collections or on exotic floras in which they have a special research interest" (p. 230).

O. H. FRANKEL's recommendation followed the same line: "... any botanic garden should restrict the number of taxa which it seriously wishes to protect" and "the main emphasis should be on ecologically suited taxa which you expect to be maintained in your botanic gardens over long periods". A reasonable genetic diversity of the population sample — he stressed — "is a matter of insurance even under protected conditions" and is much more important "if the object is re-establishment in the wild state". According to him, the genetic

diversity will be "far more effectively preserved over an ecological transect". From the point of view of the succesful re-establishment, he underlined the importance of the study of breeding systems and the autecological aspects of the taxa concerned, as well as the synecology of the community in which they are to be established (p. 247).

Theoretically, the so-called gene banks or seed-banks offer the most efficient method for preservation of samples of threatened plant populations. No significant genetic alterations could be observed in seed samples stored at temperatures of -18 °C to -20 °C and at a moisture content of $5 \pm 1\%$ in sealed containers. In order to restore the viability of stored seed samples there is a need of cyclic rejuvenation by sowing and seed growing. The genetic integrity of rejuvenated samples may be influenced by selection, outcrossing, and random fixation of some alleles (drift). These questions and others, connected with the seed bank program (quarantine problems, documentation, etc.) were shortly but very convincingly discussed by W. HANDELMAN (Braunschweig). He emphasized that the seed banks have been given first priority for preservation purposes, because the establishment of natural genetic reserve areas for cultivated plant species as well as for their wild relatives and primitive forms would be a rather unrealistic task (p. 213—222).

Special research topics were discussed by J. HESLOP-HARRISON (reproductive physiology) and C. D. COOK, Zürich (autecology). Special cultivation techniques and research programs connected with them were outlined by H.-H. POPPENDIECK, Hamburg (Mesembryanthemums), by T. BÖCHER and O. OLSEN, Copenhagen (arctic glasshouses), and by K. R. WOOLLIAMS, Hawaii (propagation of Hawaiian species). Especially distressing is this report announcing that almost 50% of the known Hawaiian species — mostly endemic ones — are under severe stress or facing extinction!

Another very important group of articles dwelt at length on different systems of documentation and data processing (Ö. NGILSSON, Uppsala; J. CULLEN, Edinburgh; F. H. PERRING, Huntington, England; M. HOFMAN, Konstanz, F. G. R.). All authors and reasoners concurred that a sound and unified system of data recording and processing would be a prerequisite for information exchange and for a successful co-operation among conservation-oriented botanic gardens and other institutions. Some basic requirements of the international co-operation were outlined by O. H. FRANKEL. He stressed that all living plant collections and especially the botanic gardens have to work in the long run and to have a clearly understood time scale of concern in their activities bounded with conservation or preservation of endangered wild plant species or populations.

E. S. AYENSU (Smithsonian Institution, Washington) argued that botanical institutions should play a pivotal role in conserving as many as possible of the threatened species. He underlined the importance of research works on plants about whose biological syndromes and natural habitat regimes we have not enough information. The international exchange and sharing of materials and information as well as a propaganda activity for the countenance of conservation efforts — are the necessary steps in a conservation program (pp. 259—267) .

G. LL. LUCAS (Kew, England) shortly summarized recent developments in international cooperation and legislation in plant conservation. Of first importance is the setting up of the Threatened Plant Committee (TPC) by the Survival Service Commission of the International Union for Conservation of Nature and Natural Resources (IUCNNR). Another major development outlined by Mr. LUCAS was the Convention on International Trade in Endangered Species of Wild Fauna and Flora, which has been signed in Washington in early 1973 and came into force on 25th August 1975. The full text of this Convention and the Conference resolution are added to the Conference material too.

The sum up, this book contains many valuable ideas, information, and recommendations not only for the curators and managers of botanic gardens and other living plant collections but for all specialists interested in problems of natural conservancy.

B. JANKÓ

M. MARÓTI: A növényi szövettenyésztés alapjai (The bases of plant tissue cultivation) 1976, 345 pp. 147 illustrations. Akadémiai Kiadó, Budapest

The results of plant tissue culture achieved in the past decades have made it possible to use the in vitro sterile techniques as a method of theoretical and applied research in plant physiology and genetics, in plant breeding and in agricultural practice. Thus, laboratories of plant tissue cultivation have been and are being set up in the fairly various fields of plant research for the application of sterile breeding techniques. The rapid and wide spread of the method have necessitated the publication of a comprehensive handbook in Hungarian.

Professor Mihály MARÓTI has been dealing with plant tissue cultures for more than a quarter of a century at the Loránd Eötvös University of Budapest. His own experiences and the literary results are successfully composed in his book, which is the first of its kind of a comprehensive handbook in the specialist literature in Hungarian and which can be fruitfully used by researchers and specialists dealing with plant tissue cultures in their work.

In the book consisting of seven chapters, the author discusses the various fields of plant tissue cultivation mainly from plant physiological and methodological viewpoints. Following the Introduction and List of Abbreviations, in Chapter II the notion purpose and use of isolated cultivation is presented and its history is summarized from WOCHTING (1878) and HABERLANDT (1902) up to our days (1975).

One of the vital requirements of a fruitful plant tissue cultivation is carrying out experiments for and composing the suitable culture medium. The organic and inorganic components of the culture medium is dealt with in Chapter III. The value of this Chapter is increased by the fact that the author deals in detail with the role, importance and effects of the various nitrogen sources, carbo-hydrates, vitamines, stimulants and inhibitors in the metabolism of the isolates. Chapter IV deals with the growth, differentiation and organogenesis of the isolated plant parts. In this chapter, the author deals separately with embryo and ovule cultures and organ cultures (shooting, root, leaf, flower, fruit, anthera) as well as their in vitro growth and development. In this Chapter, also the technical questions of callus cultures and cell cultures, the problems of their growth and differentiation are dealt with. Finally, a short summary is provided on the most important problems and results of the research related to protoplast cultures. In this Chapter the author discusses for too much of the material and it would have been more advantageous from the viewpoint of readers or researchers using the book if separate chapters had dealt with the material grouped according to certain conceptions.

After Chapter V, which is devoted to the various kinds of callus tissue cultures, Chapter VI deals with the fields of application of tissue cultures. Unfortunately, this Chapter has a shortcoming in so far as it does not indicate the fields of genetics and breeding in spite of the fact that relevant references and inferences are found in abundance in Chapter IV.

Chapter VII provides a number of useful pieces of advice for laboratories which are being set up. It discusses the general methodological questions of in vitro techniques, and describes the most important nutrient mediums.

The value of the book is greatly increased by the fact that, in addition to the discussion of the various subjects, there are detailed references at the end of the various chapters, and also the terminology and the basic notions related to the isolated plant parts are given. A further advantage of the book, which was published in 1976 that the literature of 1975 is treated in it in a still appreciable way.

In a last analysis it can be stated that the elaboration of the subject attains the standard of books published in English on tissue cultures, it supplies a long-felt need in Hungarian specialist literature, and it can be used with success by researchers and specialists dealing with tissue cultures.

L. HESZKY

SCHULTZ, V., EBERHARDT, L. L., THOMAS, J. M. and COCHRAN, M. I.: A bibliography of quantitative ecology. 1976. DOWDEN, HUTCHINSON and ROSS. Stroudsburg, Pennsylvania. pp. 1–361.

The authors compiled their bibliography from the following consideration: of late years, the application of mathematics and statistics in ecology has increased to such an extent that the compilation of a relatively many-sided bibliography has become a necessity.

Great attention has been paid to the use of mathematics and statistics in ecology, and besides, the application of computers has not been neglected either. The works containing standard mathematical and statistical methods have been included only in such cases if they contain a detailed discussion of the methods as well.

The periodicals which where considered important have been dealt with from the first issue up to 1974.

When grouping the material they were faced with several difficulties (for example, the delimitation of subjects, category of certain publications, classification, etc.).

The number of subject groups had to be restricted; the survey of the literature belonging in the theory of genetics and evolution has not even be attempted.

The bibliographical matter has been grouped according to the following categories: age, age structure; compartment models; competition, density dependence and regulation; computers and data procession; simulation; cyclic phenomena; diversity; energetics and pro-

ductivity; utilization, treatment and control; frequency distributions; growth of individuals; growth of population; mathematical models; population models; stochastic models; operation research and programming; ordination; patterns; plotless sampling; plots and quadrats; population dynamics; population estimation methods of capture and recapture; population estimation (other methods); reproduction; sampling; survival and mortality; taxonomy; books, bibliographies and educational matters. The volume ends with an index.

The bibliography overwhelmingly contains American and zoologist authors; it is only sporadically that, besides J. Ecology, European periodicals are to be found (for example, Oikos, Ecologiya), and authors are even rarer. The fact that S. Bródy's book and the volume entitled Proc. First Internat. Congr. of Ecology are missing is very conspicuous.

With regard to viewpoints of botanists it is hardly understandable that the book of Vasilevits, and Šešták-Čatský-Jarvis has been left out of the volume; further, that the activities of D. M. de Vries among the Dutch botanists, and of N. Numata among the Japanese, as well as that of R. McIntosh among the North Americans have not been discussed.

To place Bertalanffy to letter V in the alphabetical order is puzzling for us Hungarians.

Certain subjects (for example, niche) are difficult to be found in the applied categories.

The remarks mentioned do not diminish the value of the volume from which a survey of the North American ecological literature is available for the European researchers.

I. Précsényi

Hutchinson, G. E.: A Treatise on Limnology. Vol. III. Limnological Botany, John Wiley & Sons, New York—London—Sydney—Toronto, 1975, 660 pp. 164 Figs, 76 Tables

Legions of researchers the world over deal with the most varying scientific problems, the number of publications increases astonishingly even in the seemingly most insiginficant fields of science. This flood of publication is even more increasingly observable in limnology, for a significant part of environmental pollution caused by mankind infects waters and this presses intensive research forward. It is only the safety-belt of good summarizing works that can offer an escape from the sea of publications which inundates everything. The term compilative work used to have a slightly degrading sense, this, however, has been blown away by the wind of modern times. An appropriate compilative work has by all means more value than even an independent work of medium standard. This is even more so when the compilation is of a creative character. Hutchinson's book is not merely a dry enumeration of the most important articles written on the subject, but the factual material is also transmitted through the furnace of a personality of encyclopaedic knowledge, therefore the work is to a considerable extent an individual production. This book can serve as an example of how to write on a scientific subject at a high intellectual standard, but at the same time within the capacity of everybody, and imbued with a deep love of nature. The author throws light with imposing certainty and brevity upon the biochemical, physiological, histological, etc. background of the phenomena described and he does so in such a distinguished English style that even a reader with medium-level familiarity with the language is forced to look up his dictionary rather frequently, which, however, causes at the same time a great deal of pleasure as well. The book is devoid of two faults frequently occurring in such books: ignoring the metric system and leaving the European works — and even more those from the socialist countries — out of consideration. The authors' conception on nomenclature (e.g. *Phragmites australis*) is modern, but in justified cases he is prepared to compromise (e.g. *Schoenoplectus-Scirpus* problematic) and — very agreeably — delimits himself from the extreme cases of nomenclature (i.e. from the *Cyanophyta* conception of Drouet and Daily). The Bibliography consists of 38 pages and like a Baedeker of the specialist literature indicates the more important works with an asterisk. The book possesses such advantages as can be appreciated by the reader also in the preceding volumes. The chapters are easily surveyable, they begin with an introduction, are satisfactorily divided into sections and closed with a summary. A list of the geographical location of the lakes discussed is also provided in this volume. The use of the book is facilitated by a general index and an index of genera and species of organisms.

The book contains the following six chapters: The Lower Rooted Vegetation; The Nature and Diversity of Aquatic Tracheophytes; Biological Characteristics of the Tracheophytes of Inland Waters; The Chemical Ecology of Freshwater Macrophytes; The Distribution of Macrophytes in Lakes; The Algal Benthos.

It is too difficult to emphasize anything from the book. Table 7 has great significance from general limnological viewpoints; Classification of life-forms and growth-forms of higher aquatic plants; and Table 8; A comparison of the scheme of ecological classification used in the present work . . . The former chaos of nomenclature has been successfully eliminated and a well-comprehensible system has been created. Where an extremely small number of autecological data is available HUTCHINSON makes a great number of little-known experimental results public property. The terminology of algal benthos is by no means uniform the world over and from this, possible, misunderstandings may arise. This problem may be solved only if the system of a widely-known work of great influence is generally accepted and specialists would use it. Haptobenthos and Herpobenthos used in this work would indeed be satisfactory for this purpose.

The friends of the preceding two volumes will not be disappointed by the third volume either and, what is more, we may be convinced that this third volume will assist the first two ones in attaining friends for themselves, too.

L. HAJDU

BÖHM, Anton (1976): Morphologische Studien im Bereiche der Pyrrhophyta. Das Problem Form und Selektion. Bibliotheca Phycologica Ed. 22. J. CRAMER in A. R. GANTNER Verlag Kommanditges. Vaduz, 119 pp., 32 plates, 197 figures.

The aim of the subject, as is explained in the summary by the author himself, is "to point out and promots the liquidation of the view and prejudicies that have been set for a long time, taken over without criticism and accumulated infinitely". The results: the form of the Pyrrhophytas does not play a part in the improvement of the floating movement; further, it does ot serve any of the tasks supposed by the literature. In the case of *Pyrrhophyta*, a uniform notion of species is in principle impossible, since the importance of the morphe and the tabulation is not known, and the frequent interception (overlapping) of these two characteristics results in a completely incomprehensible situation. The reality of the progressive form lines and the parallel trends makes the effect of intern factors (that is, a common inheritory stock) unstead of the extern factors probable. There are signs of both intraspecific and transspecific evolution. The final question of the work is whether the form has a part to play, or whether it has to have a part to play in selection.

A young scientist, at the beginning of his career, considers every problem as a simple one. The more, however, he works deeper into a field, the problems look the greater, while the question increasingly more unsolvable. Possibly, in an extreme case the aim is no longer to find a solution but to find a problem. The notions and methods of all the biological science branches are burdened with faults. Nevertheless, the positive features and the negative ones should be brought into equilibrium, since the one-sided mentioning and exaggeration of the unsolved problems lead to cynical standpoints, and puts a question-mark whether further work is at all reasonable. This doubting in everything can be felt in BÖHM's work, and it is perceptible immediately at the first glance of the frequent occurrences of quotation marks, exclamation marks and question marks.

Algae taken in the traditional sense embrace such a large organizational and ecological domain that no statement valid for all of them without exception (and only for them) can be made. Let us call the statement an algal rule.

In terms of this thought, BÖHM engages in discussion with the theory that the appendages and the form serve the improvement of floating. He contravenes this hypothesis by means of analysing the floralists in literature. The reviewer who, dissimilarly to the authors, has not spent his whole life in studying the *Pyrrhophyta*, cannot judge to what extent the contra-examples not mentioned here influence the conclusion. Nevertheless, in the very sense of the algal rule, we cannot agree with the exaggerating final conclusion that the form is always unimportant in floating movement uptaking the nutrient, preventing against grazing etc. We have known since DARWIN that the organs that have lost their functions show an extreme variability. The existence and great stability of these morphological marks suggest that the algae do use them for something. There is rigorous economy in nature; no self-contained, functionless formations can be general. Because, on the basis of our present knowledge, we cannot still recognize the function we cannot make the statement that it has never had an importance in selection, in niche segregation, etc.

The book will be of use for not only those dealing with evolution theory and genetics but also for taxonomists. The author analyses — even though in an exaggerating way — such problems that exist actually. It is true that the mechanical theory of expedience and selection

is in principle condemned by everybody, nevertheless, in explaining concrete cases, everybody makes frequent use of it. If in such cases those who have read the book turn not immediately to the most convenient explanation of expedience but meditate whether such a connection can exist here, then it can be inferred that the book has achieved the aim set to it. Enjoying it within bounds, the reader will be able to acquire — if he has not yet done it — the sound doubting and problem-seeing necessary for a right taxonomical attitude. It is a pity that the book has been published only in German; the danger of ignoring it from the side of English-speaking countries threatens is.

L. HAJDU

PIELOU, E. C. (1975): Ecological Diversity. John WILEY & Sons, Inc. New York. pp 165.

The aim of the author was, as she states in the preface: ". . . a short state-of-the-art book would be useful to the many research workers and graduate students who are concerned with, or about to start work upon, this topic."

The volume is divided into 8 chapters. The first deals with the indices of diversity and evenness. There are described three diversity indices (SHANNON-WEAVER, BRILLOUIN and SIMPSON-index), and three indices for measuring evenness $J'\left(=\frac{H'}{\log S}\right)$, $V\left(=\frac{H-H_{\min}}{H_{\max}-H_{\min}}\right)$, as well as the "equitability index" according to LLOYD and GHELARDI). A more detailed review can be found in earlier book of the author (PIELOU, 1969, An introduction to mathematical ecology. WILEY, New York).

The problems concerning sampling processes are also included in this chapter. The method for estimating diversity of large communities seems a little labourous.

Chapter 2 describes three, so-called resource apportioning models, the niche preemption, the broken stick and the overlapping niche models. In the former two there is supposed to be a limiting resource, shared among the species coexisting in the same area. In the third one, no such limiting resource is assumed. The three models give species-abundance distributions which can be compared with the observed ones. Their testing is described in Chapter 4.

In Chapter 3, some probability distributions are outlined, e.g. the truncated negative binomial, the logseries and the lognormal distributions.

In Chapter 5, the problem of the diversity and stationary spatial pattern is discussed, as well as two tests (based on the χ^2 distribution) to judge whether a species can occur in a community as separate individuals rather than as patches, randomly mingled. It is shown that the mosaic character of the community affects the species-individuals diversity, therefore the spatial diversity of the community investigated must be taken into account, calculating the real species-individuals diversity of the community. This is done by use of conditional probabilities.

Chapter 6 deals with the problem of communities, whose pattern shows an unidirectional variation, i.e. with the zoned communities. First the competition model is described, for two species coexisting along a gradient (in Subchapter 6.2.). Subsequently the author deals with the so-called "beta diversity", or "species turnover" along a gradient. The measure of beta diversity (the term used by WHITTAKER) is based on the similarity of two quadrates on the gradient. The lesser the similarity between two quadrates getting more and more distant from each other is, the greater the value of β $(0 \leq \beta \leq 1)$. The greater the change in species composition is, the higher β becomes. Here we must point out that the uncritical use of the term "diversity" can lead to misunderstandings, since the word "diversity" in the term "beta diversity" does not mean the same as the concept used on other pages of the volume. The term "species turnover" instead of "beta diversity" is much better.

In 6.4. we find a method for comparing zone patterns in different communities based on the coefficient of concordance.

Subchapter 6.5. deals with the problem of the "continuum concept" and the "integrated community concept", i.e. with the problem whether species depend only on the abiotic factors of the environment, or on the presence of the other species occurring in the same area as well. In the former case, the boundaries of the zone occupied by a single species will be located randomly and independently along the gradient, in the latter case they will form batches. A third case too is also possible, when the species are so adapted to the environmental conditions (biotic or abiotic) that the zone boundaries tend to be spaced evenly along the gradient. There is also a method given to test the three hypothesis for a given empirical situation.

In the last two Chapters (7 and 8) the author deals with the factors (in the widest sense of the word) which result in the given species-abundance relations, i.e. diversity. In Ch. 7, she

touches upon (as a review) the problems of niche, species packing, and coexistence of competitors, with a great number of references. In 7.4. and 7.5. the population interactions in a patchy habitat are discussed, outlining two models, the model proposed by SKELLAM and that by HORN & MACARTHUR.

Chapter 8 contains a process to calculate niche width and overlap, based on an $m \times n$ contingency table (m species and n locations). In the same chapter, there are briefly discussed the stability-predictability-productivity hypothesis related to diversity, the diversity on small islands, and the temporal changes in diversity through geological time.

There is a great number of diversity and evenness indices and functions used or proposed in the literature, and most of them is defined merely by the function used to calculate them. Therefore it would have been rather important to deal with the concept of diversity itself. This concept does exist (see: JUHÁSZ-NAGY, P. 1973, Bot. Közlem., 60: 35—41). In the volume, the concept of diversity is used only in a narrow sense, for most of cases as species-individuals diversity. The lack of clarification of the concept can be misleading (as mentioned above, in connection of the term "beta diversity"), for example in subchapters 8.4. and 8.5., where the term "diversity" is used in the sense of species number. The species-individuals diversity is only a special case of diversity, the concept itself is more universal. It is a basic phenomenon of all systems where a partition can be made, and it reflects on the spectral structure of the given collection. That is, it is valid not only for synbiological systems. (See: DÉVAI, I.—HORVÁTH, K.—JUHÁSZ-NAGY, P. 1971, Ann. Univ. Sci. Budapest. Sect. Biol., 13: 19—32.; JUHÁSZ-NAGY, P. 1973, Bot. Közlem., 60: 35—41.).

Considering the aim of the author as stated in the preface ". . . a short state-of-the-art book . . .", it would have been worth while outlining also other diversity functions, e.g. the "mutability index" proposed by GINI (see LETI, G. 1965, Metron, 24: 332—378), the index submitted by MCINTOSH (MCINTOSH, R. P. 1967, Ecology, 48: 392—404), the "Number of Moves" and "SD" suggested by FAGER (FAGER, E. W. 1972, Amer. Nat., 106: 293—310), the HILL-ratios (HILL, M. O. 1973, Ecology, 54: 427—432), etc. These papers, and other comprehensive reviews (e.g. CANCELA DA FONSECA, J. P. 1966, Bull. Mus. Hist. Nat. Paris, 38: 961—968; 1969, Rev. Écol. Biol. Sol., 6: 1—30 and 533—555; PEET, R. K. 1974, Annual Rev. Ecol. Syst., 5: 285—307: NOSEK, J. N. 1977, Acta Bot. Acad. Sci. Hung., in press), are not included in the bibliography either. It should be noted that the last one was published too late to be included in the reference list.

The volume is well illustrated, both by examples and illustrations. It is a useful starting point to gather information in the field and whoever intends to delve deeper into one of the problems can find instructions in the bibliography.

J. N. NOSEK

INDEX

ACTA BOTANICA

ТОМ 23 ВЫП. 1—2

РЕЗЮМЕ

ИССЛЕДОВАНИЕ ФИТОПЛАНКТОНА НА ОЗЕРЕ ВЕЛЕНЦЕИ (ЧИСЛО ВОДОРОСЛЕЙ И БИОМАССА)

Ж. БАРТА

На основании исследования количества особей и биомассы в 13-ти точках озера Веленцеи в 1973—1974 году, было выделено при площади, отличающихся друг от друга по альгологии, а также внутри этой площади можно было выделить переходной, или с какой-либо точки зрения индивидуальный тип воды. Сгущенность планктонных водорослей в сборных пунктах северо-восточного озера очень высокая, это место планктонной эвтрофизации. На площади юго-западного озера сгущенность особей низкая и в результате бентонической эвтрофизации питательные вещества не образуются в фитопланктоне. В середине озера трофичность воды небольшая, число особей в фитопланктоне находится между двумя выше названными территориями, а на дне нет водяных растений. Различия между величинами, полученных при измерении оводорослення вместе с биомассой не такие крайние, как при измерении числа особей. На оценку биомассы влияют виды большие по размеру (***Peridiniopsis borgei*** Lemm. ***Botryococcus braunii*** Kütz, а виды, которые по своему обьему меньше 100^3, только тогда влияют на изменение величины, если сгущенность особей более миллиона. Автор показала, что на территории озера, различающейся по наличию водорослей состав видов фитопланктона тоже различный.

ЭКОФИЗИОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ ГАЛОФИТОВ В СУХОЙ И ПОЛУСУХОЙ ЗОНЕ

I. АВТОЭКОЛОГИЯ ГАЛОФИТА LIMONIASTRUM MONOPETALUM (L) BOISS ВЫДЕЛЯЮЩЕГО СОЛЬ

К. Х. БАТАНОУНИ и М. АБО СИТТА

В статье описывается первая часть из серии исследования галофитов, произрастающих в сухих и полусухих зонах. В этой части дается описание египетских галофитов. ***Limoniastrum monopetalum***, выделяющий соль галофит, произрастает в западной медитерранной зоне Египта, со слабым суб-пустынным климатом. Однако растительные сообщества преобладают в мало-засоленных условиях на песчанных почвах. Для характерно, что они имеют потенциальную способность формировать насыпи. Формирование этих насыпей имеет много экологических последствий посредством эффекта связи между водой, растениями и почвой. Формирование этих насыпей имеет много экологических последствий посредством эфекта связи между водой, растениями и почвой. Формирование этих насипей идет параллельно с ростом растений и достигает значительного размера высотой 50 см и выше. При формировании насыпей развивается два типа корней: пучки коротких, нежных корней и длинных волокнистых корней. Оба способствуют значительному впитыванию воды растениями. Растения имеют два различных типа желез, различающихся своим распределением по телу растения, структуре и функции. Это соляные железы и слизистые железы. Железы, выделяющие соль находятся на листьях и молодых корнях. Каждая заключает в себе 16 клеток, 12 из них выделительные, а 4 дополнительные. Слизистые железы находятся на оболочке листа, на поверхности эпидермиса, каждая состоит из различного числа клеток и заключает в себе большое число не выделительных, дополнительных клеток.

НОВЫЙ РОД АНТИЛЬСКИХ ОСТРОВОВ TETRAZYGIOPSIS, А ТАКЖЕ РОД НА КУБЕ TETRAZYGIA L. C. RICH. (MELASTOMATACEAE).

А. БОРХИДИ

В данной работе дается таксономическая ревизия кубинского рода *Tetrazygia* L. C. Rich. Впервые описаны 3 вида, 2 варианта и 2 комбинации этого рода. Кроме этого предлагается новый аналитический ключ. При помощи этой ревизии можно распознать новый род, растущий на Атиллак, и отличающейся от рода *Tetrazygia* по стуркутре чашечки. Этот род получил название *Tetrazygiopsis* и содержит 2 секции и 8 видов.

СТРОЕНИЕ ЦЕЛЛЮЛОЗНОЙ ОБОЛОЧКИ В НЕСКОЛЬКИХ ТИПАХ КЛЕТОК ГАМЕТОФИТА MARCHANTIA POLYMORPHA L. I. КЛЕТКИ НИЖНЕЙ СТОРОНЫ ЭПИДЕРМИСА, ГЛАДКИЕ РИЗОИДЫ, РИЗОИДЫ С УТОЛЩЕННЫМИ ШИПОВИДНЫМИ КЛЕТКАМИ

Я. ДЕМЕТЕР-СИЛАДЬИ, И. ВОЙНАРОВИЧ-ХРАПКА

В данной статье дается отчет о строении целлюлозной оболочки клеток нижней части эпидермиса гаметофита с гладкими и шиповидными ризоидами при помощи светового, поляризационного и электронного микроскопа сканнинг. Эти три типа клеток различны не только по своей форме и размеру, но и по суб- и светомикроскопическому строению. Это подтверждает тот взгляд, что различная функция клеток проявляется и в особенности строения оболочки клеток. Исследования показали, что в случае нижней части клеток эпидермиса и в случае гладких ризоидов различия в строении наблюдается в тех же самых типах клеток между различными оболочками клеток и в зависимости от того с какой стороны они находятся. Это подтверждает ранее известные данные о том, что одинаковые типы дифференцировались внутри клетки а также в связи с функцией оболочек клеток.

Данные о клетках нижней стороны эпидермиса а также данные о дифференциации и росте основной части оболочки клеток шиповидных ризоидов показывают, что для развитой оболочки клетки характерно то, что утолщенные формы появляются задолго до полного развития клетки. Косвенные исследования клеток нижней стороны эпидермика в антиклинарных оболочках клеток гладких и шиповидных ризоидов указывали на перпендикулярную ориентацию микрофибрилл горизонтальной плоскости колоний. Этот факт демонстрирует перпендикулярную микрофибрильность в сравнении длины роста клеток и колоний. В отростковой части обоих типов ризоидов микрофибриллы располагаются параллельно продольной оси отростков так, что с ростом этой части клетки имеется возможность судить о микрофибрильности. Были показаны ориентации микрофибрилл в гладких и щитовидных отростках ризоидов волнистого профиля (следующими по движению винта), а также в основании гладких ризоидов (круговое) и в щитовидных утолщениях стенки клетки (лучистое). Электронно-микроскопические исследования гладких ризоидов в ранней стадии подтвердили результаты косвенных опытов.

СВЯЗЬ ПРОДУКЦИИ НАДЗЕМНОЙ ФИТОБИОМАССЫ С СОДЕРЖАНИЕМ ХЛОРОФИЛЛА У РАСТЕНИЙ, ПРОИЗРАСТАЮЩИХ НА ЛЁССОВОПУСТЫННЫХ ПОЧВАХ В КОНДИЦИОНАЛЬНЫХ И ГРУНТОВЫХ УСЛОВИЯХ

Л. ЭНДРЕДИ, И. ХОРВАТ

Авторы исследовали взаимоотношение надземной продукции фитобиомассы с содержанием хлорофилла в кондициональных (в световой камере) и грунтовых условиях у видов, находящихся в четырех фондах ассоциации.

Авторы показали тесную позитивную, линеарную, регрессивную связь между продукцией фитобиомассы и содержанием хлорофилла, рассчитанного на продукции сухого веса. При сравнении результатов, полученных в кондициональных и грунтовых условиях авторы не получили существенных различий.

ИНДЕКСЫ РАЗНООБРАЗИЯ ВИДОВ ВОДОРОСЛЕЙ В ДВУХ ЕВТРОФНЫХ РЫБНЫХ ОЗЕРАХ I

Л. ХАЙДУ

Видовая разновидность по SHANNON в меньшей степени приближается к возможному максимуму ($\log_2 b$) в более эвтрофном озере, чем в менее эвтрофном и ее абсолютная величина тоже меньше. В большей части года число видов ($r^2 = +0{,}5271$) определяет разнообразность, что показывает тесную корреляцию с продолжительностью дневного света ($r = +0{,}7260$ $p < 0{,}13\%$) и слабую с инсоляцией ($r = +0{,}1999$).

В небольшой части года в образовании разнообразия главную роль играет равномерность. В это время наблюдается максимальное количество водорослей и вместе с этим увеличенная аглимитация питательных веществ. Можно предположить, что в это время селективное подавление размножившихся синих водорослей влияет и на понижение равномерности. Среднее число видов выше, средняя равномерность ниже в эвтрофном озере и обе тенденции увеличиваются во время увеличения числа водорослей (выше 100 миллионов на литр). Индэкс MARGALEF находится в корреляции с индэксом SHANNON. Параметры, рассчитанные с большей точностью не дали значительно лучших результатов, потому что данные по водорослям рассчитывались старыми методами и они дали неточные статистические результаты. Авторы изображают полученные данные в колонной диаграмме.

ИЗУЧЕНИЕ ТИПА АССИМИЛЯЦИИ У ВИДОВ ПЕСЧАННО-СТЕПНОГО ДЁРНА

А. ХОРАНСКИ, А. Х. НАДЬ

В работе приводятся данные по изучению типа ассимиляции 30 видов, произрастающих на песчанно-степном дёрне около "Kis Tece" Вацратота (*Festucetum vaginatae*, *Festucetum wagneri*). Из всех исследованных видов, растущих в местах с полупустынным жарким, сухим микроклиматом, четыре были типа C_4, семь C_3 и семь C_{3-4}, вернее переходного типа. Двенадцати видам невозможно было дать оценку из-за кислотной реакции.

ЭЛЕКТРОННОМИКРОСКОПИЧЕСКИЕ ИЗУЧЕНИЯ ИСКОПАЕМОЙ ПЫЛЬЦЫ ANGIOSPERMATOPHYTA ПАЛЕОЦЕННОЙ И СРЕДНЕЭОЦЕННОЙ ЭРЫ

М. КЕДВЕШ

Пыльца *Angiospermatophyta* палеоценной и эоценной эры была исследована при помощи электронного микроскопа СЭМ. Эти исследования привели к новым результатам, которые не были получены при помощи светового микроскопа. Настоящая работа также подтверждает значение СЭМ при исследовании ископаемой пыльцы.

ДЕКОМПОЗИЦИЯ ЛЕСНОЙ ПОДСТИЛКИ, ОСВОБОЖДЕНИЕ БИОГЕННЫХ ЭЛЕМЕНТОВ В ЛАБОРАТОРНЫХ УСЛОВИЯХ

М. КОВАЧ

В данной статье автор исследует декомпозицию лесной подстилки более часто распространенных видов деревьев и кустарников, входящих в состав дубового леса (*Quercus cerris*) и освобождение биогенных элементов в лабораторных условиях. Более 50% количества биогенных элементов освобождается за три – четыре месяца из лесной подстилки. Самый быстрый и в самом большом количестве выделяется калий. Зеленые листья разлагаются быстрее, чем осенние сухие листья (лесная подстилка).

НОВЫЙ ВИД POACEAE (GRAMINEAE) PHLEUM HUBBARDII KOVÁTS

Д. КОВАЧ

Описана новая серия (Series *Pratenses*) и новый диплоидный вид *Phleum hubbardii* Kováts $2n = 14$.

Известны холотипы LINNÉ *Phleum nodosum* — DE CANDOLLE *Phleum bertolonii*. Ранее какой-то из этих двух видов отождествляли с диплоидом *Phleum pratense* L. Размеры двух холотипов были сравнены с размерами *Ph. hubbardii* Kováts ($2n = 14$) и гексаплоидным *Ph. pratense* L. Автор определил, что выше названные два холтипа не диплоиды, а слабые еще не вытянувшиеся растения, тождественные гексаплоиду *Ph. pratense* L. При сравнении некоторых свойств и размеров органов диплоидного *Ph. hubbardii* Kov было определено, что между двумя этими видами разница не только квантитативная (между диплоидными и гексаплоидными органами разница меньшая), а также квалитативная (из 10 исследованных свойств в 9-ти имеется разница).

ИЗУЧЕНИЕ ФИТОПЛАНКТОНА ЗАЛЫ

Ё. НЕМЕТ, Э. ВИЗКЕЛЕТИ

Авторы изучали фитопланктон Залы в 1972—1976 годах с качественной и количественной точки зрения. В результате подробной таксономической обработки фитопланктона авторы определили 191 таксон (*Cyanophyta* II, *Euglenophyta* 8, *Xanthophyceae* 1, *Chrysophyceae* 2, *Bacillariophyceae* 125, *Cryptophyceae* 1, *Volvocales* 3, *Chlorococcales* 37, *Desmidiales* 3, Авторы изучили определенное число таксонов, которое относилось к целому исследованному времени года и которое росло по направлению устья реки. На всех участках самым большим было количество таксонов диатомовых водорослей. Число таксонов *Chlorococcales* увеличивалось по продольной оси реки на уровне отношения *Chlorococcales: Bacillariophyceae.* В процессе количественных исследований фитопланктона авторы определили его процентный состав и распространение, а также общее число водорослей и количество хлорофилла «а» в единичном объеме воды. Для фитопланктона характерна *Chrysophyta*, а внутри этого вида в первую очередь доминантность диатомовых водрослей уменьшается по направлению устья Залы. Оценка параметров распределения и степени трофизма одинаково росла по направлению устья и достигала максимальной оценки обыкновенно в районе устья.

Эти изменения можно связать с загруженностью участка реки под Залаэгерсэг растительным питательным материалом, а также с уменьшением скорости реки.

ИССЛЕДОВАНИЕ АФРИКАНСКИХ CALYMPERACEAE

Ш. ОРБАН

Автор работает над ревизией африканских видов *Syrrhopodon* и *Calymperes.* В этой статье он описывает вид *Syrrhopodon tanzaniae* (секция *Cavifolii*). Автор дополняет определение *Syrrhopodon stuhlmannii*, главным образом на основе материала, который был собран Поч Тамашем в Танганьике. Автор обращает внимание на структуру края листа, который отличается от других видов этого рода, и который имеет эволюционное значение. На основании этого автор открывает новую секцию (секция *Tricostatae*)

ВЛИЯНИЕ ВЫРУБКИ ЛЕСА НА ПРОДУКЦИЮ УРОВНЯ МЯГКОСТЕБЕЛЬНЫХ ДУБОВОГО ЛЕСА

М. ПАПП

Автор занимается в статье исследованием биологической продукции леса *Quercetum petraeae-cerris*, находящейся иа территории «Sikfőkút Project» (JAKUCS, 1973), на которой лесники в сентябре 1973 года вырубили лес с последующей целью сплошной вырубки. В результате разросшейся кроны деревьев и удаления уровня кустарников окружающие

условия сильно изменились, в особенности количество солнечных лучей, которые доходил до уровня мягкостебельных.

В работе характеризуются количество особей мягкостебельных видов и изменение покрова, а также изменение количества фитомассы и продукции двух доминантных видов. Эти данные сравниваются с данными нетронутого леса.

Автор определил, что число особей приходящихся на 1 гектар и покров увеличились в 6,0 - 6,5 раз по сравнению к нетронутому лесу. А количество фитомассы и продукции увеличилось в 10—30 раз.

ПРИМЕНЕНИЕ АНАЛИЗА NICHE ДЛЯ НЕКОТОРЫХ ВИДОВ ПЕСЧАННОСТЕПНЫХ АССОЦИАЦИЙ II. СЕЗОННАЯ ДИНАМИКА

И. ПРЕЧЕНЬИ, Г. ФЭКЭТЭ, Э. МЭЛКО, Э. МОЛЬНАР

Авторы в первом сообщении обобщили данные исследований проведенных летом 1976 года, сравнивая полученные оценки на основе различных измерений niche. В данной статье описываются результаты осенних измерений, а также сравниваются летние и осенние результаты. Осенние измерения тоже происходят на оси 2 niche (содержание влажности почвы, максимальная глубина корневой массы, связанная с использованием площади) и относятся к девяти видам.

На оси влажности почвы и летом и осенью ширина-niche *Festuca vaginata*, составляющей сообщество, самая большая. Летне-осенняя ширина-флуктуация **niche** на оси глубины корней более сильная, чем на другой. Осенью в случае хорошего снабжения почвы водой, средняя оценка **overlap** поднимается, но это не означает растущую компетицию.

В двух измерениях площади (комбинации категории двух факторов) каждый индэкс **overlap** показывает низшую оценку, чем некоторые факторы, расположенные по отдельности по осям. По матрицу **community, community effect**, принимая во внимание вид, составляющий сообщество (*Festuca*) самый сильный. Самый большой эффект вида пришельца *Cynodon dactylon.* У большинства видов двойное влияние подвергается сильной сезонной флуктуации. В двух измерениях площади niche самого большого размера достигает экологическая изоляция *Fumana procumbens:* она не влияет на сообщество и сообщество на нее.

СРАВНИТЕЛЬНЫЙ АНАЛИЗ НОРМАЛЬНОГО И СПОНТАННОГО МУТАНТА ALBINA ТАБАКА NICOTIANA SYLVESTRIS SPEG. ET COMES

Л. СИЛАДЬИ, А. Х. НАДЬ

В статье дается сравнительная цитологическая и биохимическая характеристика нормального и спонтанного мутанта дикого вида табака *N. sylvestris* **Speg. et Comes.**

Мутант **albina** спонтанно возник в 1974 году в гаплоидной культуре *N. sylvestris* и с тех пор сохраняется со стабильным фенотипом. Авторы определили, что **albina** мутант сохраняет свой гаплоидный уровень ($n = 12$), тогда как зеленые растения в значительной степени диплоидизировались.

Мутант с хлорофильным дефектом и в нем отсутствует фиксация CO_2. Значительные различия между мутантом и зеленым растением наблюдаются при сравнении полученных спектров дегидрогеназы яблочной кислоты, пероксидазы и эстеразы.

ЧИСЛОВАЯ ОЦЕНКА ФЕНОТИПИЧЕСКОГО РОДСТВА ВЕНГЕРСКИХ ВИДОВ GENTIANA

Ю. СУЙКО-ЛАЦА, С. СЕН

Авторы дали числовую оценку похожих и различающихся между собой различных морфологических признаков у видов *Gentianella ciliata* (1), *Gentiana pneumonanthe* (2), *G. cruciata* (3), *G. asclepiadea* (4), которые по мнению Р. Шоо (1966) относятся к роду *Gentiana*. В этой статье даются результаты обработки гербария, находящегося в ботаническом

музее. Авторы выбрали 43 различных морфологических признака из различных органов растений и сравнивали их в форме политомичного ключа. Восемь из них были обработаны при помощи вариантного анализа, для квантитативной характеристики морфологического характера. Из 43 характеристик 10 у каждого из четырех видов были одинаковые, а семь были похожи у 2,3,4 вида.

Большая степень схожести у видов *G. pneumonanthe*, *C. cruciata* и *G. asclepiadea* может быть выражена в процентах, тогда как между 43 характеристиками *G. ciliata* 23 отличались от других трех видов.

На основании данных видно, что 13 и 14 признаки вместе, 26 и 42 по отдельности— это такие признаки, по которым четыре вида отличаются друг от друга.

Между 5 вегетативными и репродуктивными органами квантитативно были показаны сигнификантные различия. У большинства видов различия наблюдались в 29 и 36 признаке.

На основе квалитативных и квантитативных результатов авторы соглашаются с определением Frolich (1796), Grisebach (1839), Kusnecov (1896), Tutin, Heywood (1973), что *G. ciliata* относится к роду *Gentianella*.

КАРПОЛОГИЧЕСКИЕ ИЗУЧЕНИЯ ДИКОРАСТУЩИХ ВИДОВ ВИНОГРАДА В ВЕНГРИИ КАЧЕСТВЕННАЯ И КОЛИЧЕСТВЕННАЯ ХАРАКТЕРИСТИКА СЕМЯН ВИНОГРАДА

А. ТЭРПО

Во второй части статьи автор дает отчет о морфологических исследованиях семян винограда. В первую очередь на основании формы и скультуры семян *V. sylvestris* автор подразделяет свойства на классы. Семена *V. sylvestris* характеризуются на основе 1 и 2-х семянных ягод. Семена *V. sylvestris* большей частью округлые, клювик семени короткий и конический, плечи семени широкие, клинчатые, дорзальная сторона острого рисунка, халазный щиток широко-овальный, формы капли или круглый.

Борозды вентральной стороны в большей части слабо вилообразные (формы V) или расположенные параллельно. Вес семян венгерских типов *V. sylvestris* 2,19–3,34 гр. а вес семян *V. vinifera* (cv. **Kövidinka**, cv. **Kadarka**, cv. **Kékfrankos** и. тд) 1,79–2,87 гр. Количество семян в каждой ягоде у растений *V. sylvestris* с среднем с 17 образцов —1,70, а у *V. vinifera* больше 2,09. По исследованию регрессии объема ягод в образце *V. riparia* между ростом количества семян в каждой ягоде и объемом ягоды только с двухсемянными ягодами есть корреляция. У *V. sylvestris* в больших ягодах обыкновенно образуется больше семян.

АНАТОМИЯ ДРЕВЕСИНЫ CERATOPYXIS HOOKER F. EX HOOKER (RUBIACEAE) (МОНОТИПИЧНЫЙ ГЕНУС, РАСТУЩИЙ НА ЗАПАДНОЙ ТЕРРИТОРИИ КУБЫ)

М. А. ВАЛЕС, К. БАБОШ

Работа дает описание анатомии вторичной ксилемы породы *Ceratopyxis verbenacea* растущей на западной территории Кубы. Наша статья содержит данные о сосудах, волокнах, сердцевинных лучах и продольных паренхимах, а также некоторые морфологические и экологические характеристики.

Работу проводили при помощи статистических методов и сравнением данных определяли изменения в сосудах и длинах волокна.

НОМЕНКЛАТУРА OPHRYS FUCIFLORA

Х. У. УИРТ

Автор делает обзор истории исследования *Ophrys fuciflora* aue. rec и пытается уточнить номенклатуру этого вида. На основе номенклатурных разъяснений автор считает, что *Ophrys fuciflora* (F. W. Schmidt) **Moench**—правильное название.

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NOTAS SOBRE ACANTÁCEAS CUBANAS I. OPLONIA Y ELYTRARIA

Por

A. Borhidi

INSTITUTO DE BOTÁNICA, ACADEMIA DE CIENCIAS DE HUNGRÍA, VÁCRÁTÓT, HUNGRÍA

by

O. Muñiz

INSTITUTO DE BOTÁNICA, ACADEMIA DE CIENCIAS DE CUBA, LA HABANA

(Llegado: 25 de julio, 1977.)

The first part of the present study contains a discussion on some taxonomical problems of the genus *Oplonia* Raf. and an amplified new analytical key to the complete genus, further contributes the descriptions of 4 species and 1 subspecies new to science (*O. moana* sp. n., *O. cubensis* sp. n., *O. multigemma* sp. n., *O. Acunae* sp. n., and *O. spinosa* ssp. *insularis* ssp. n.) and a more complete redescription of some critical species: *O. nannophylla* Urb., *O. tetrasticha* (Wr. ex Griseb.) Stearn, *O. polyece* (Stearn) Borhidi. The second part contains a new analytic key to the Cuban species of the genus *Elytraria* Michx., with descriptions of 2 species and 1 subspecies new to science (*E. spathulifolia* sp. n., *E. filicaulis* sp. n. and *E. planifolia* ssp. *Acunae* ssp. n.) and finally describes a new *Stenandrium* species (*S. heterotrichum* sp. n.).

1. El género Oplonia Raf.

Sobre este género un estudio muy notable fue publicado por W. T. Stearn (1971). Este autor encontró, que el género antillano *Anthacanthus* Nees y el género madagascano *Forsythiopsis* Baker son identicos y su más antiguo nombre genérico válido es: *Oplonia* Raf. Stearn realizó una serie de investigaciones multifaceticas sobre las espécies de este género, incluidos varios intentos de classificarlas objetivamente a base de 24 caracteristicas morfológicas elegidas utilizando distintos métodos estadísticos de la taxonómia numérica. Además el autor analizó la distribución geográfica de las espécies, discutió la importancia paleo-fitogeográfica de la disyunción de la distribución de este género sacando numerosas conclusiones interesantes. En cuanto a la elaboración taxonómica del género, Stearn distingue 14 espécies y 4 variedades, — entre ellos 2 espécies y 2 variedades nuevas para la ciencia, — además mapificó la distribución geográfica de cada taxones estudiados.

Los autores del estudio presente realizaron colectas abundantes en todas partes de Cuba, para tener materiales de estudiar suficientes, para hacer observaciones directas sobre los cambios morfológicos en las distintas fases ontogénicas y para estudiar las condiciónes ecológicas, que permiten la existencia y desarrollo de las espécies de *Oplonia* en Cuba. Basandonos en estas observaciones e investigaciones llegamos a las conclusiones siguientes:

1. Las espécies antillanas del género *Oplonia* pueden listarse en dos grupos: a. espécies poco variadas de areas pequeñas (*O. jamaicensis*, *O. purpu-*

rascens, O. multigemma); b. espécies de poblaciones muy variadas, mayormente con una distribución geográfica más amplia, (*O. spinosa, O. tetrasticha*).

2. En ciertas espécies (*O. nannophylla, O. spinosa, O. cubensis*) la variabilidad morfológica de la misma planta puede ser más grande durante su desarrollo individual, que la diferencia específica entre dos espécies relacionadas. Por esta razón es necesario conocer bien la variabilidad individual de las distintas espécies, las propiedades morfológicas de los renuevos primarios y secundarios, retoños, etc. e incluirlas detalladamente en las descripciones. Tenemos que subrayar la importancia de las observaciones de las plantas vivas en el campo durante por lo menos un ciclo vegetativo.

3. Los intentos de la clasificación numérica de las espécies de este género realizados por W. T. STEARN no aportaron un resultado positivo, lo que nos hace pensar que las caracteristicas morfológicas utilizadas para este fin, no fueron bien seleccionadas. Según nuestras experiencias obtenidas en plantas cubanas 10—11 de las 24 caracteristicas consideradas por STEARN tienen valor taxonómico dudoso o débil, — por lo menos — en este género, (por ejemplo: largo de internodios, pubescencia de tallos, pedicelos y corola, la base redondeada o el ápice emarginado de las hojas etc.); por otra parte encontramos algunas caracteristicas morfológicas más confiables y de mayor importancia taxonómica (por ejemplo: textura, margen y estructura del epidermis de las hojas, presencia o ausencia y morfología de los cistolitos y glándulas en las hojas, relación del tubo y lóbulos de la corola, etc.), que no fueron tenidas en consideración por STEARN. Además, consideramos la ramificación efectiva y potencial (presencia de las yemas) de las espinas, como una caracteristica específica importante y geográficamente muy bien delimitada, la que se encuentra solamente en la provincia de Oriente, y allí caracteriza 3 distintas espécies bien definidas.

4. Observábamos, que las espécies cubanas tienen areas ecológicamente muy controladas. Las espécies, que viven en caliza no pueden migrar a la roca serpentina, e igualmente, las zonas de serpentina tienen también sus taxones exclusivamente própios. Tenemos por poco probable, que la misma *Oplonia spinosa* (Jacq.) Raf. cresca en las montañas de serpentina del origen paleógeno en Oriente, la que vive en las calizas costeras neógenas o cuaternarias en las demás Antillas y Bahamas. Pensamos, que las poblaciones serpentinicolas de la *O. spinosa* agg. pertenecen a una espécie distinta y morfológicamente distinguible, la que nosotros llamamos *O. cubensis* Borhidi. De manera parecida se distinguen en Cuba Occidental las poblaciones de la espécie costera *O. tetrasticha* y la serpentinicola *O. nannophylla*. (Véase: la fig. 2.)

Casi no hay localidad o biótopo, donde los individuos de dos espécies distintas crescan juntos. La unica zona excepcional es la Costa Sur de la Sierra Maestra, donde se hallan algunas poblaciones de las espécies *O. tetrasticha*,
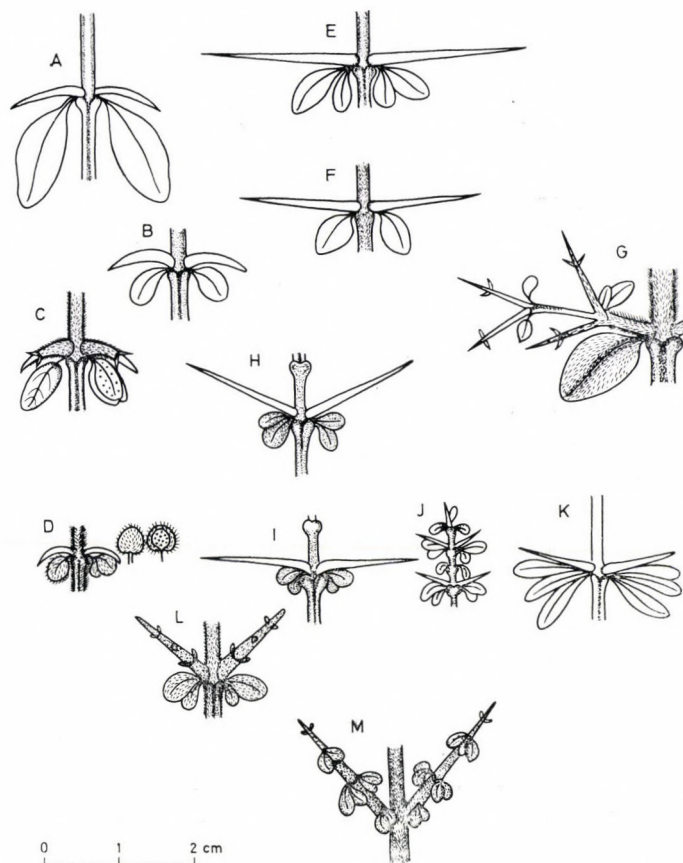
Fig. 1. Espinas y hojas en algunas espécies del género *Oplonia* (orig.). A: *Oplonia spinosa* (Jacq.) Raf. ssp. *spinosa* (BUCH, 1851, Haiti); B: *O. spinosa* ssp. *insularis* Borhidi (CURTISS 133, New Providence, Bahamas); C: *O. cubensis* Borhidi (holotipo: BORHIDI, VALES y OVIEDO SV); D: *Oplonia moana* Borhidi (holotipo: SAMEK 26819 SV); E: *O. tetrasticha* (Wr. ex Griseb.) Stearn (Cuba: Peninsula de Guanahacabibes, Punta Holandés, BORHIDI y OVIEDO); F: *O. tetrasticha* (isotipo, WRIGHT 3067, Cuba Occidental); G: *O. polyece* (Stearn) Borhidi (Cuba; Playa Pesquero Nuevo, BORHIDI); H, I, J: *O. nannophylla* (Urb.) Stearn (H, Cuba; Loma de Coca, Campo Florido; BORHIDI, VALES y MONCADA; I: Loma Preluda de Cajalbana; BORHIDI y CAPOTE; J: holotipo, EKMAN 19534); K: *O. purpurascens* (Griseb.) Stearn (isotipo, WRIGHT 3066, Cuba Occidental); L, M: *O. multigemma* Borhidi (L: Cuba; Ceja de Melones, BORHIDI, Bp; M: holotipo, LÓPEZ FIGUEIRAS 1367 SV)

O. polyece y *O. Acunae*. Las espécies cubanas del género *Oplonia* — y evidentemente las de Jamaica también — son vicariantes, que mutualmente se reemplazan en sentido geográfico u ecológico. (Véase fig. 3.).

Clave analitica para el género *Oplonia*:

1 a Plantas inermes, hojas de 2—10 cm de largo 2
b Plantas mayormente armadas por espinas axilares, (inermes en la *O. minor* y *O. linifolia*); hojas de 0.1—4 cm de largo 6
2 a Hojas acuminadas a agudas en el ápice, lóbulos del cáliz ± de igual largo (4.5—5 mm), como el tubo de la corola 3
b Hojas obtusas o redondeadas en el ápice, lóbulos del cáliz más cortos que el tubo de la corola de 5—10 mm de largo 4
3 a Flores 7—10 en cada axila; hojas estrechamente cuneadas en la base (Peru) .... **1. O. grandiflora** (Lindau) Stearn
b Flores 1—3 en cada axila, hojas redondeadas en la base (Madagascar) . ... **2. O. acuminata** Stearn
4 a Lóbulos de la corola más cortos del tubo, estilo glabro (Jamaica) .... **3. O. jamaicensis** (Lindau) Stearn
b Lóbulos de la corola más largos del tubo, estilo pubérulo 5
5 a Lóbulos del cáliz estrechamente triangulares, esparcidamente pelosos (Madagascar) .... **4. O. vincoides** (Lam.) Stearn
b Lóbulos del cáliz estrechamente oblongos, densamente pubescentes (Madagascar) .... **5. O. puberula** Stearn
6 a Plantas inermes 7
b Plantas espinosas 8
7 a Hojas elípticas o estrechamente obovadas (Madagascar) .... **6. O. minor** (Benoist) Stearn
aa Hojas y cáliz glabros a glabrescentes .... aaa
bb Hojas y cáliz pubérulos .... **var. vestita** (Benoist) Stearn
aaa Hojas de 2—9 mm de largo y 1—4 mm de ancho .. **var. minor**
bbb Hojas de 12—25 mm de largo y 4—10 mm de ancho .... **var. meridionalis** (Benoist) Stearn
b Hojas lineales (Madagascar) .... **7. O. linifolia** (Benoist) Stearn
8 a Espinas recurvas o deflexas 9
b Espinas rectas, horizontalmente extendidas o ascendentes 11
9 a Espinas muy delgadas de hasta 5—6 mm de largo, hojas muy pequeñas de 1—3 mm, orbiculares, aovadas a cordiformes, densamente hirsuto-vellosas a glabrescentes (Cuba: Oriente: Moa) **8. O. moana** Borhidi
b Espinas más largas y gruesas, hojas elípticas u obovadas, más grandes y glabros 10
10 a Espinas todas simples; el margen de las hojas plano (Bahamas—Islas Virgenes) .... **9. O. spinosa** (Jacq.) Raf.
aa Hojas coriáceas, cistolitos lineales, prominulos en ambas caras ... . **9a. ssp. spinosa**
bb Hojas membranáceas a cartáceas, mates, cistolitos lineales en el haz, puntiformes en el envés .... **9b. ssp. insularis** Borhidi

b Espinas con yemas o brevemente ramificadas; hojas coriáceas, nítidas, el margen revoluto, cistolitos lineales prominentes en el haz, puntiformes en el envés (Cuba: Norte del Oriente) ..... **10. O. cubensis** Borhidi

11 a Espinas de 3—15 mm de largo, mayormente delgadas a veces ausentes 12

b Espinas de 1—3 cm de largo, rígidas, fuertes, simples o ramificadas 17

12 a Arbustico muy denso y postrado de hasta 10—15 cm de alto, espinas delgadas ascendentes, internodios muy cortos, hojas de 1—3 mm de largo (Cuba Occidental) .... **16. O. nannophylla** (Urb.) Stearn

b Arbustos más altos y extendidos, internodios de más de 1 cm de largo, hojas de 3—40 mm 13

13 a Pedicelos de 1—2 mm de largo, más cortos del cáliz; hojas elípticas (Cuba: Mogotes de Pinar del Rio) . **11. O. purpurascens** (Griseb.) Stearn

b Pedicelos mayormente más largos del cáliz 14

14 a Espinas ascendentes con 2—6 pares de yemas, hojas de 2—5 mm de largo, aovadas, redondeadas a subacorazonadas en la base; flores en grupos 3—6-floros (Cuba: Oriente: Serpentinas de Holguin) .... **17. O. multigemma** Borhidi

b Espinas sin yemas, hojas más grandes, cuneadas o estrechadas en la base, flores solitarias o en fasciculos 2—4-floros 15

15 a Corola blanca, estambres siempre inclusos, filamentos de 0.8 mm de largo, más cortos de las anteras; hojas mayormente más anchas bajo la mitad (Jamaica) .... **12. O. acicularis** (Sw.) Stearn

b Corola roja, purpurea o morada pálida o azul, muy raramente blanca; estambres exsertos o insertos, filamentos de 1.5—7 mm de largo, más largos de las anteras 16

16 a Hojas de 3—12 mm de largo y 1.5—6 mm de ancho, elípticas u obovadas, pecíolos de hasta 1 mm; flores 1—2, pedicelos de 2—7 mm de largo (Jamaica) .... **13. O. microphylla** (Lam.) Stearn

b Hojas de 5—40 mm de largo y 3—20 mm de ancho, aovadas, elípticas u obovadas, pecíolos de 2—5 mm de largo; flores solitarias o en fasciculos 2—4-floros, pedicelos de 5—15 mm de largo (Jamaica) .... **14. O. armata** (Sw.) Stearn

aa Corola roja; hojas mayormente más anchas bajo de la mitad ... . **var. armata**

bb Corola purpurea o morada pálida o casi blanca; hojas mayormente más anchas en la mitad .... **var. pallidior** Stearn

17 a Espinas todas simples sin yemas, flores 1—2 18

b Espinas con yemas o ramificadas; flores mayormente en fasciculos 19

18 a Hojas membranáceas a cartáceas, mates, de 6—15 mm de largo, con cistolitos lineales en el haz y puntos glandulosos en el envés (Cuba) .... **15. O. tetrasticha** (Wr. ex Griseb.) Stearn

b Hojas subcoriáceas a coriáceas, nítidas, de 1—3 mm de largo, pelosas

a glabras, con cistolitos prominentes y puntos glandulosos hundidos en ambas caras (Cuba Occidental) .. **16. O. nannophylla** (Urb.) Stearn

19 a Espinas sencillas, ascendentes, con 2—6 pares de yemas, mayormente hojosas en las ramas adultas, hojas de 2—5 mm de largo, aovadas, redondeadas a subacorazonadas en la base, flores en grupos 3—6-floros en las axilas o sobre las espinas (Cuba: Oriente: Serpentinas de Holguin) .... **17. O. multigemma** Borhidi

b Espinas siempre ramificadas, horizontalmente extendidas, hojas de 6—20 mm de largo 20

20 a Hojas mayormente cartáceas, mates, con cistolitos lineales en el haz, puntiformes y lineales en el envés, puntos glandulosos poco conspicuos, tubo de la corola igual o más largo que los lóbulos (Cuba: Costas de Oriente) .... **18. O. polyece** (Stearn) Borhidi

b Hojas mayormente coriáceas, nítidas, cistolitos inconspicuos en ambas caras, puntos glandulosos aparentes en el envés; lóbulos de la corola más largos del tubo (Cuba: Or.: Sierra Maestra) **19. O. Acunae** Borhidi

Oplonia moana Borhidi sp. n.

Frutex ramosus, spinosus. Rami hornotini brunnescentes, circumcirca breviter patenti-pubescentes, internodiis 4—7 mm. longis, leviter quadrangulares. Spinae tenues, leviter recurvatae, simplices, 3—5 mm. longae, basi 0,5 mm. crassae, in ramis vetustioribus rariter absentes. Folia dimorpha, breviter et tenuissime petiolata, ad ramos hornotinos orbicularia vel late cordata, 2—4 mm. longa et 2,5—4 mm. lata, apice rotundata et basi truncata, rotundata vel leviter cordata, ad ramos vetustiores elliptica, apice obtusa et basi cuneata, 3—5 mm. longa et 1,5—3 mm. lata, omnia supra ± dense hirsuta, subtus glabrescentia, concavo-bullata, margine valde revoluta, supra cystolithis linearibus crassis prominentibus, subtus nervo medio crassiuscule prominulo et cystolithis punctiformibus suffulta, coriacea. Cetera ignota.

Holotypus: SV 26819!; Cuba; Prov. Oriente, Mina Potosi, Moa. Leg.: V. Samek, Mai. 1968. Isotypus: Bp!

Specim. exam.: Oriente: Cupeyal del Norte, Rio Toa; leg.: A. Borhidi, O. Muñiz et S. Vazquez 3248! 9. febr. 1970. — Cerro de Miraflores, Yaguaneque, Moa; leg.: A. Borhidi, R. Capote et Ramona Oviedo, 12. sept. 1974.

Obs.: *O. cubensi* Borhidi affinis, quae a specie nostra foliis majoribus ovatis et glabris, spinis tenuibus brevibusque differt.

Oplonia spinosa (Sw.) Stearn ssp. insularis Borhidi ssp. n.

A typo differt: foliis minoribus, membranaceis vel chartaceis, utrinque opacis, supra cystolithis linearibus, subtus punctiformibus suffultis.

Holotypus: Curtiss 133 in Herb. Acad. Sci. Cuba SV!; (isotypi: BM; F; GH; K), Insulae Bahamenses, New Providence prope Nassau; 24. mart. 1903.

Oplonia cubensis Borhidi sp. n.

Frutex usque ad 1—2 m. altus. Rami ascendentes, teretes, glabri vel circumcirca vel faciebus oppositis dense breviterque pubescentes. Spinae conspicue curvatae, plerumque horizontaliter elatae vel ad ramos juveniles breviter adscendentes et rectae, plerumque puberulae, apicem versus quasi semper 2-gemmatae vel leviter trifurcatae, 2—10 mm. longae, basi usque ad 1,5 mm. crassae. Folia subsessilia vel 1—2 mm. longe petiolata, plerumque ovata vel elliptica, sub medio vel in medio latissima, apice obtusa et emarginata, rariter acuta, basi plerumque obtusa vel rotundata, 4—15 mm. longa et 1,5—5 mm. lata, nervo medio supra profunde impresso, subtus crassiuscule prominenti, lateralibus supra leviter impressis, sed plerumque utrinque nullis; lamina supra obscure viridis, nitida vel lucida, papilloso-areolata et cystolithis quaqueversis crassiuscule prominentibus rugulosa, subtus pallidior, cystolithis punctiformibus et glandulis impressis punctata, sparse pubescens vel glabra, margine valde revoluta, crasse rigideque coriacea. Flores axillares plerumque 3—6, fasciculati, pedicelli 2—7 mm. longi, glabri. Calyx 2—4 mm. longus, lobi anguste triangulari-subulati, cystolithis punctati, glabri. Corolla plerumque profunde violacea, glabra, tubus 5—10 mm. longus, lobi late obovati 4—5 mm. longi; stamina inserta vel exserta, filamenta 0,5—1 mm. vel 3—5 mm. longa, antherae usque ad 1,5 mm. longae; stylus 1 cm. longus. Capsula obovata, apice acuminata et acuta cca. 1 cm. longa, glabra.

Holotypus: Cuba; Prov. Oriente. Sierra del Cristal; in fruticetis serpentinosis montanis cacuminis Mt. Cayo Verde in alt. 850 m. s. m., Corea, Mayari Arriba. Leg.: A. BORHIDI, M. VALES et RAMONA OVIEDO, 10. apr. 1976. SV !; isotypus: Bp !.

Specim. exam.: Sierra del Cristal: Mayari Arriba; Charrascos cerca de la cresta del Cristal. Leg.: 2—7. apr. 1956. ALAIN, ACUÑA et LÓPEZ FIGUEIRAS 5701 (SV !), 5703 (SV !), 5708 (SV !), 5810 (SV !); — Cayo Verde, in pinetis, alt. 700—765 m. s. m.; leg.: 10. apr. 1976. A. BORHIDI, M. VALES et RAMONA OVIDEO (SV !, Bp !); — Region de Moa: Cayo Chiquito, Moa; leg.: 18. mai. 1944. CLEMENTE 2346 (SV !), — Mina Franklyn, leg.: 20. mai 1944. CLEMENTE 3665 (SV !), — Cerro de Miraflores, leg.: jul. 1942. LEÓN et MONTERO 21152 (SV), — Ibidem, leg.: 12. sept. 1974. A. BORHIDI, R. CAPOTE et RAMONA OVIEDO (SV !, Bp !), — Playa de Vaca, leg.: apr. 1943. MARIE-VICTORIN, CLEMENTE et ALAIN 21503 (SV !). — Ibidem, leg.: 9. nov. 1945. ACUÑA (SV !), — Ibidem leg.: 25. mart. 1970. A. BORHIDI, O. MUÑIZ et S. VAZQUEZ (SV !), Rio Cayoguán, leg.: ALAIN et CLEMENTE 856 (SV !), — Falda NO del Rio Toa, Cupeyal, leg.: 10. febr. 1970. A. BORHIDI, O. MUÑIZ et S. VAZQUEZ 3409 ! (Bp et SV); Sierra de Nipe: Pinares de Mayari, leg.: 18. jul. 1970. A. BORHIDI, O. MUÑIZ 8210 !

Obs.: *O. spinosae* (Jacq.) Raf. affinis, quae a specie nostra spinis simplicibus, tenuioribus, non gemmatis, plerumque glabris, foliis plerumque membranaceis vel chartaceis, margine non revolutis differt.

Oplonia tetrasticha (Wr. ex Griseb.) Stearn

(Syn.: *Anthacanthus tetrastichus* Wr. ex Griseb. in Catal. Plant. Cub. 1866. p. 195. sensu Wr. non STEARN)

Frutex ramosissimus, spinosus, rami decumbentes vel ascendentes, hornotini flavicantes, quadrangulares, circumcirca breviter puberuli vel longius hirsuti (typus !); spinae simplices, rigidae, rectae, setaceae, horizontaliter patentes, folia subduplo superantes, 0,7—2 cm. longae, basi usque ad 1 mm. crassae; folia breviter petiolata, obovata vel anguste elliptica, apice rotundata et leviter mucronata, basi cuneata, 5—10 mm. longa (incl. petiolum), 2,5—5 mm. lata, utrinque glabra, supra cystolithis tenuibus prominulis suffulta, subtus glanduloso-punctata, membranacea vel papyracea. Flores 1—2, axillares, pedicelli 4—7 mm. longi, glabri vel sparsissime stipitato-glandulosi. Calyx 2,5—4 mm. longus, lobi calycis subulati, quasi usque ad basem incisi. Corolla pallide violacea vel violacea, in fauce purpureo- vel brunneo-punctata, glabra vel puberula(?); tubus 4,5—10 mm. longus, lobi 3—4 mm. longi: stamina inclusa vel exserta, filamenta 1—4 mm. longa, antherae 1,5 mm. longae.

Typus: WRIGHT 3067 in Cuba Occidentali (SV isotypus !).

Specim. exam.: Pinar del Rio: Peninsula de Guanahacabibes, leg.: ACUÑA et ZAYAS, 23. jul. 1955 (19945 SV!), — Punta del Holandés, leg.: A. BORHIDI et RAMONA OVIEDO, 23. mart. 1976. — Habana: Valle de Almendares, dec. 1908. leg.: LEÓN 465 !; — Loma de Machado, Jibacoa, 2. jan. 1929. leg.: LEÓN et ROIG 13756 ! — Matanzas: Punta Guanal, leg.: 30. mai. 1974. A. BORHIDI, E. DEL-RISCO, R. CAPOTE SV ! — Boca de Canasi, 17. oct. 1928. leg.: LEÓN 13696 (SV) ! — Peninsula de Zapata, Paso Malo, leg.: 13. mart. 1975. A. BORHIDI et E. DEL-RISCO SV ! — Las Villas: Cienfuegos, Pasa Caballo, leg.: A. BORHIDI et O. MUÑIZ, 21. aug. 1969. SV ! — Cienfuegos, Gavilán, 23. mart. 1928. leg.: JACK 5815 SV ! — Loma de Guajabana, Caibarién, leg.: ACUÑA 24. febr. 1952. 17514 SV !

Obs.: La *Oplonia tetrasticha* es una espécie calcicola de las costas y lomas costeras y crece exclusivamente en rocas calizas en la parte occidental de Cuba, desde la Peninsula de Guanahacabibes hasta la provincia de Las Villas. Todos los ejemplares de *Oplonia*, colectados en las zonas serpentinas de Cuba Occidental, pertenecen a la espécie *O. nannophylla* (Urb.) Stearn.

Oplonia nannophylla (Urb.) Stearn

Esta espécie fue descrita por URBAN en base de un ejemplar colectado por EKMAN (16534 S) cerca de Guanabacoa en las Lomas de Jata, en 3 de Junio, 1923. Recolectando ejemplares de esta espécie en varias localidades observaba, que la descripción era basada en una forma extrema, destruida varias veces por fuego, que perdió toda su potencia regenerativa en la habitad seca y extremadamente pobre en nutrientes. Observé también, que ejemplares viejos, — parecidos al del tipo — desarrollaban ramas juveniles estériles caracterizadas por espinas y hojas pequeñas, delgadas y densas, además desarrollaban ramas largas, fértiles con espinas largas, fuertes y hojas pequeñas, coriaceas. De esta manera llegé al resultado que la *Oplonia nannophylla* (Urb.) Stearn es una espécie comun de todas las areas serpentinas de Cuba Occidental, y sus ejemplares normales estuvieron confundidas a menudo por los botánicos, con los ejemplares de la *Oplonia tetrasticha* (Wr. ex Griseb.)
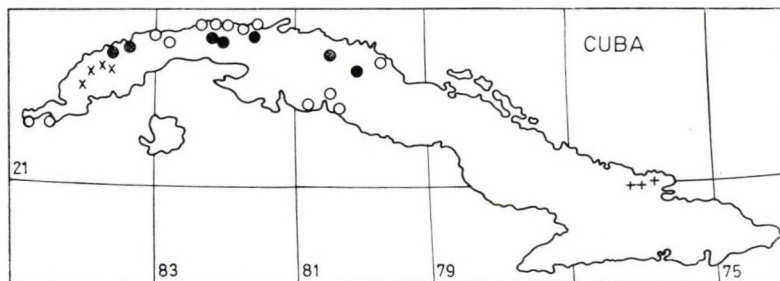
Fig. 2. Distribución geográfica de las espécies *Oplonia tetrasticha* ○; *O. nannophylla* ●; *O purpurascens* x; y *O. multigemma* +

Stearn. Por esta razón considero necesario hacer una redescripción completa de ambas espécies. El diagnosis de la *Oplonia nannophylla* (Urb.) Stearn es como sigue:

Frutex usque ad 1 m. altus. Rami hornotini teretes vel leviter compressi, circumcirca breviter dense hirsuti, glabrescentes vel glabri, vetustiores teretes, cortice longitudinaliter fisso; internodiis in ramulis juvenilibus secundariis 1—5 mm. longis, in ramis vetustioribus 4—8 mm. longis, nodi sub spinis valde incrassati, cicatricibus petiolorum delapsorum obtecti. Spinae supra axillis foliorum solitariae, ad ramos juveniles tenues, adscendentes, rectae, ad ramos vetustiores a basi adscendentes horizontaliter vel subhorizontaliter directae vel leviter ascendentes, rectae vel basi levissime curvatae, 0,8—2 cm. longae, simplices, egemmatae, brevissime hirsutae vel glabrae. Folia subsessilia, obovata vel obovato-elliptica, basi plerumque in petiolum angustata, 1—3 mm. longa et 0,7—1,5 mm. lata, spinis multo breviora, nervo medio supra inferne prominulo vel obsoleto, subtus initio paullo prominenti, apicem versus evanescenti, lateralibus utrinque nullis; lamina supra obscure viridis, nitida, cystolithis quaqueversis, crassiuscule prominentibus obsita, subtus pallidior, cystolithis obsoletioribus et punctis glandulosis impressis suffulta, supra pilosa, brevissime glanduloso-hirsuta vel glabra, utrinque nitida, crassiuscule rigideque coriacea. Flores axillares 1—(—2); pedicelli 5—10 mm. longi, glanduloso-pilosi vel glabri. Calyx 1,5—2 mm. longus, lobi quasi usque ad basem incisi, 1,3—1,8 mm. longi, triangulari-subulati, glanduloso-pilosi vel glabri. Corolla profunde violacea, utrinque pilosa vel glabra, fauce brunneo-punctata, 7—10 mm. longa, tubus 4—7 mm. longus, lobi obovati, 3—5 mm. longi. Stamina inserta, filamenta 1—3 mm. longa, ovarium ovatum, apice acuminatum, 2—3 mm. longum, glanduloso-pilosum vel glabrum. Stylus 3—4 mm. longus, apice breviter capitatus. Capsula oblanceolata, acuminata, 0,7—1,5 cm. longa rariter brevior.

Specimina examinata: Prov. Pinar del Rio: Loma Preluda de Cajalbana, in fruticetis serpentinosis, leg.: 28. jan. 1976. A. Borhidi et R. Capote SV !, Bp ! — Ibidem 28. apr. 1976. leg.: A. Borhidi et R. Capote SV !, Bp ! — Cuabales al Este de la Loma de Cajalbana, La Palma, leg.: 10. jun. 1950. Alain et Acuña 1395 (SV !) — Ibidem febr. 1953. Alain 2757 (SV !), apr. 1954. 3901 !, 3909 ! (SV). — Falda Sur de la Loma Cajalbana, leg.: Acuña et Roig jul. 1951 (SV) ! — In fruticetis serpentinosis ad Bahia Honda, leg.: A. Borhidi, R. Capote et J. Urbino, 26. aug. 1975. (SV) ! — Prov. Habana: Lomas de las Jatas 3. jun. 1923. leg.: Ekman 16534 (typus S !), — Ibidem, Ekman 16530 ! — Ibidem, León 2865 ! 4. jan. 1912 (SV !) — Loma de Coca, Campo Florido, leg.: A. Borhidi et O. Muñiz 19. sept. 1969. (SV !) — Ibidem, leg.: A. Borhidi, M. Vales et Milagros Moncada 10. dec. 1974. — Prov. Matanzas: Loma

Galindo, Piedra Sola, Corral Nuevo; leg.: A. BORHIDI, E. DEL-RISCO et R. CAPOTE 30. mai. 1974 (SV)! — Prov. Las Villas: Sabana de Motembo, 2. jun. 1919. LEÓN et FORTÚN 8579 (SV)! — Ibidem, 28. aug. 1922. LEÓN 11385 (SV)! — Cerro Chivo, Santa Clara, leg.: 3. sept. 1969. A. BORHIDI, O. MUÑIZ et S. VAZQUEZ 324 SV!

Oplonia multigemma Borhidi sp. n.

Frutex ramosus, spinosus. Rami hornotini brunnescentes, leviter quadrangulati, faciebus oppositis brevissime et adpresse pilosi, vetustiores albicantes, glabri, spiniformes. Spinae ascendentes, leviter quadrangulares, 6—12 mm. longae, rariter longiores, basi usque ad 1,5—2 mm. crassae, nodosae, 2—8-gemmiferae, postremo foliosae et floriferae. Folia brevissime petiolata, ovata vel elliptica, apice rotundata vel obtusa, basi rotundata vel breviter angustata, 2—5 mm. longa et 1,5—3 mm. lata, spinis multo breviora, nervo medio supra impresso, subtus prominenti, lateralibus utrinque nullis, lamina supra cystolithis linearibus crassiuscule prominulis, subtus commatis sparsis, plerumque ad nervum medium aggregatis suffulta, ceterum albo-punctata, utrinque nitida, glabra, margine incrassata, coriacea. Flores in axillis ad ramos hornotinos vel ad ramos laterales vetustiores spiniformes 3—6-fasciculati. Pedicelli 3—6 mm. longi, glabri vel sparse glandulosi. Calyx 3—4 mm. longus, glaber vel sparse glandulosus, lobi oblongo-lanceolati, acuti, quasi usque ad basem incisi. Corolla violacea vel pallide violacea, tubus 6—10 mm. longus, glaber, lobi valde inaequales, breviores 2—3 mm., longiores 4—5 mm. longi, glabri, omnes obovati, apice rotundati. Stamina inclusa, filamenta 1—1,5 mm. longa, antherae ovatae, 1,5 mm. longae, stylus usque ad 2 cm. longus. Capsula oblanceolata, glabra, 0,6—1,2 cm. longa.

Holotypus: LF 1367 SV! Cuba; Prov. Oriente; lomas junto Holguin, carretera de Cueto. Leg.: LÓPEZ FIGUEIRAS 30. mai. 1954. Isotypus: SV!

Specim. exam.: Prov. Oriente: in fruticetis sempervirentibus serpentinosis aridis ad Ceja de Melones inter Santa Lucia et Holguin. Leg.: A. BORHIDI 14. febr. 1976. (SV!, Bp!), — in fruticetis sempervirentibus serpentinosis montis Cerro Galano, Camino La Palma, Holguin, leg.: A. BORHIDI, R. CAPOTE, RAMONA OVIEDO 25. sept. 1975. (SV!, Bp!), — Cuabales de serpentina, Holguin, mai. 1939. Leg.: LEÓN et CARABIA 1898! (SV), — Cerro de Fraile, Holguin, 21. febr. 1970. Leg.: A. BORHIDI et O. MUÑIZ 3916! (SV, Bp).

Oplonia polyece (Stearn) Borhidi comb. et stat. n.

(Syn.: *Oplonia tetrasticha* var. *polyece* Stearn in Bull. Brit. Mus. Hist. Nat. Bot. *4*. No. 7. 1971. p. 311. — *O. tetrasticha* ssp. *polyece* Borhidi in Acta Bot. Acad. Sci. Hung. *19*. 1973. p. 45.)

Frutex ramosissimus, spinosus; rami ascendentes, hornotini flavicantes, quadrangulares, in faciebus oppositis vel circumcirca puberuli vel plerumque patente-hirsuti. Spinae primariae rectae, lignosae, 1—3,5 cm. longae, basi usque ad 2,5—3 mm. crassae, ramificatae vel 2—4-gemmiferae usque foliigerae. Folia usque ad 2 mm. longe petiolata, obovata, ovata vel elliptica, apice rotundata et saepe emarginata, basi cuneata, obtusa vel rariter rotundata, 0,6—2 cm. longa et 0,3—1,2 cm. lata, juvenilia utrinque sparse ad nervum medium subtus dense hirsuta vel longe pilosa, postremo glabrescentia vel glabra, supra cystolithis linearibus prominulis suffulta, subtus cystolithis linearibus et puctiformibus obsoletis vel manifeste prominulis albo-punctata et obsolete glanduloso-punctata, papyracea vel chartacea. Flores 2—4, axillares

vel ad spinas subsolitarii; pedicelli 3—6 mm. longi, glabri. Calyx 3—5 mm. longus, glaber vel sparse pilosus, lobi calycis subulati, quasi usque ad basem incisi, apice plerumque permanenter pilosi. Corolla pallide azurea vel violacea, glabra vel sparse glanduloso-puberula, tubus 6—11 mm. longus, lobi 5—7 mm. longi. Stamina exserta, filamenta 2—5 mm. longa, antherae cca. 1,5 mm. longae. Capsula oblongo-obovata, 1—1,5 cm. longa, apice brevissime apiculata, cystolithis punctata.

Specim. exam.: Prov. Oriente: Manigua de Aguadores, Santiago de Cuba, mai. 1946. Leg.: CLEMENTE 5021 (SV !), — Ibidem, 20. oct. 1969. Leg.: A. BORHIDI et O. MUÑIZ 765 ! (SV), — El Morro, Santiago de Cuba, 12. jun. 1953. Leg.: ACUÑA et CORREL 18708 ! (SV) — Ibidem, 21. oct. 1969. Leg.: A. BORHIDI et O. MUÑIZ 828 ! 830 ! (SV, Bp); — Manigua del Aeropuerto, Santiago de Cuba, 14. mart. 1954. Leg.: LÓPEZ FIGUEIRAS 1131 (SV !); — La Socapa, 21. oct. 1969. Leg.: A. BORHIDI et O. MUÑIZ 890 ! 891 ! (SV, Bp); — Versailles, Santiago de Cuba, 3. febr. 1970. Leg.: A. BORHIDI 2693 ! (SV); — Punta Gorda, Santiago de Cuba, 6. apr. 1976. Leg.: A. BORHIDI, M. VALES et RAMONA OVIEDO (SV; Bp); — El Sardinero, Siboney, 12. febr. 1970. Leg.: A. BORHIDI, O. MUÑIZ et S. VAZQUEZ 3509 ! (SV); — Yunque de Daiquiri, 29. oct. 1969. Leg.: A. BORHIDI 1442 ! (SV, Bp); — Costa seca de Imias, Baracoa; 14—15. sept. 1952. Leg.: ACUÑA 17892 ! (SV); — Jauco, Baracoa, 17. mart. 1970. Leg.: A. BORHIDI, O. MUÑIZ et S. VAZQUEZ 4427 ! (SV, Bp); — Minas de Nicaro, Ocujal, Mayari, jul. 1953. Leg.: ACUÑA, ALONSO et PINO 18790 ! (SV); — Playa Pesquero Nuevo, Santa Lucia, 15. febr. 1976. Leg.: A. BORHIDI (SV, Bp).
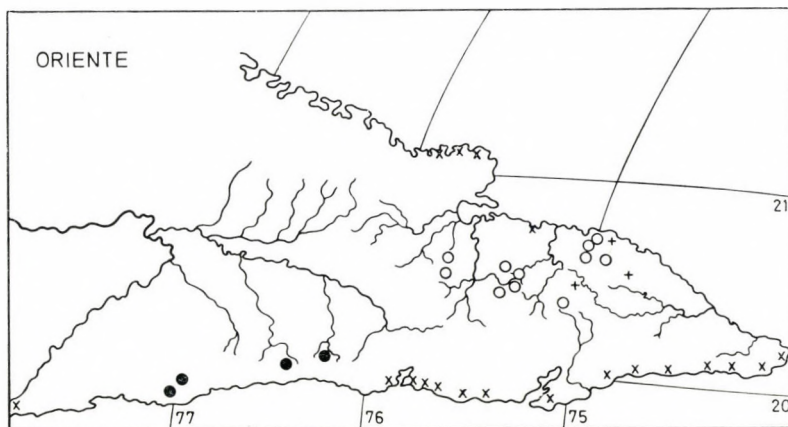
Fig. 3. Distribución geográfica de las espécies *Oplonia cubensis* ○; *O. moana* +; *O. Acunae* ●; y *O. polyece* ×

Oplonia Acunae Borhidi sp. n.

Frutex ramosissimus, valde spinosus. Rami ascendentes, hornotini flavicantes, leviter quadrangulares, circumcirca breviter puberuli vel setuloso-hirsuti. Spinae leviter ascendentes vel horizontales, rigidae, lignosae, 0,8—2,5 cm. longae, basi usque ad 2,5 mm. crassae, trifurcatae vel ramificatae, saepe foliigerae. Folia elliptica, ovata vel obovata, apice acuta vel

obtusa, basi attenuata, 0,6—2 cm. longa et 0,3—0,8 cm. lata, juvenilia cum petiolis (1—3 mm. longis) utrinque dense breviterque hirtula, postremo utrinque nitida, glabra, coriacea, cystolithis utrinque absentibus, subtus glanduloso-punctata et nervo medio lateralibusque utroque latere 2—3 prominulis suffulta, margine plana. Flores axillares, 1—3; pedicelli 4—7 mm. longi, glabri; calyx 3—5 mm. longus, glaber, lobi subulati usque ad basem incisi; corolla pallide azurea, tubo 5—7 mm. longo, lobi 6—10 mm. longi, intus brevissime lanuginosi. Capsula oblongo-obovata, 1—1,5 cm. longa, plerumque glabra.

Holotypus: ACUÑA 11239 SV!; Cuba; Prov. Oriente, Sierra Maestra, Pico Turquino. Leg.: J. ACUÑA, 2. aug. 1935. Isotypus: ACUÑA 9710 SV!

Specim. exam.: Prov. Oriente: Sierra Maestra: Mogotes de Baire prope pag. Matias in alt. 450—500 m. s. m. 23. oct. 1969. Leg.: A. BORHIDI et O. MUÑIZ 1032 (SV)! — Ibidem Pozo Azul, 23. oct. 1969. Leg.: A. BORHIDI et O. MUÑIZ 963! (SV); — Mogotes de Baire, La Tabla, 5. febr. 1970. Leg.: A. BORHIDI, O. MUÑIZ et S. VAZQUEZ 2880! (SV; Bp).

2. El género Elytraria Michx. en Cuba

El género *Elytraria* Michx. ha sido poco estudiado en Cuba. El articulo presente añade a las 3 espécies conocidas en este pais la descripción de 2 espécies y 1 subespécie nuevas más y una clave analítica para las espécies cubanas:

1 a Hojas oblongas a aovadas, cartáceas; cáliz 5-mero 2
b Hojas orbiculares o espatuladas, membranáceas; cáliz 4-mero 4
2 a Brácteas pubérulas por fuera (Cuba: LV.; Cam.; Or.; endémica) .... **1. E. Shaferi** (P. Wils.) Leonard
b Brácteas lampiñas por fuera 3
3 a Hojas fuertemente crenadas y rugosas, firmes (Cuba: Cam.; Or.; endémica) .... **2. E. cubana** Alain
b Hojas enteras o repandas, el margen denticulado o poco crenulado, mayormente entero (Cuba: PR.; LV.; Cam.; Or.; endémica) .... **3. E. planifolia** Leonard
aa Hojas aovadas de 1.5—3 cm, el margen denticulado u poco crenulado, espigas de 1—1.5 cm, brácteas de 3—4 mm de largo, cápsula de 2—3 mm .... **3a. ssp. planifolia**
bb Hojas oblongo-oblanceoladas a lineari-oblongas de 2.5—5 cm, el margen entero; espigas de 1.5—2 cm, brácteas de 5—6 mm de largo, cápsula de 3.5—5 mm (Cuba: Cam.; endémica) .... **3b. ssp. Acunae** Borhidi
4 a Pecíolo de 1.5—3 cm de largo, pedúnculo y raquis pelosos debajo de las escamas; lóbulos laterales del cáliz lineal-lanceolados (Cuba: Or.: Baracoa, sobre caliza; endémica) .... **4. E. spathulifolia** Borhidi et Muñiz

b Pecíolo de 0.5—1 cm de largo, pedúnculo y raquis muy delgados y glabros debajo de las escamas; lóbulos laterales del cáliz aovados y aristulados en el ápice (Cuba: Or.: Moa, sobre serpentina; endémica) .... **5. E. filicaulis** Borhidi et Muñiz

Elytraria planifolia Leonard ssp. Acunae Borhidi ssp. n.

A typo differt: foliis oblongo-oblanceolatis vel lineari-oblanceolatis, 2,5—5 cm. longis et 0,4—0,8 cm. latis, margine integris, spiculis 1,5—2 cm. longis et 0,5—1 cm. latis, bracteis ovatis 5—6 mm. longis, capsulis 3,5—5 mm longis.

Holotypus: Acuña 16322 SV!; Cuba; Prov. Camagüey, Sabanas entre ciudad Camagüey y Sierra de Cubitas, solo serpentinoso. Leg.: J. Acuña et E. Rodriguez, 1. aug. 1950.

Elytraria spathulifolia Borhidi et Muñiz sp. n.

Planta acaulis, radice fibrosa. Folia spathulata, limbo ipso orbiculari vel late obovato, apice rotundato, basi breviter cuneato et in petiolum 1,5—3 cm. longum et 2—4 mm. late alatum protracto, 1—1,5 cm. longo et 0,8—1,2 cm. lato, nervo medio utrinque tenuiter prominulo, longe et sparse piloso vel glabrescenti, lateralibus utroque latere 2—3, apicem versus arcuatis, utrinque prominulis et conspicue reticulatis, lamina utrinque glabra, supra viridis, subtus opaca, margine leviter crenulata, tenuiter membranacea. Pedunculi 2,5—7 cm. longi et 0,5—1 mm. crassi, apice plerumque divaricati vel ramificati, spiculas 1—3 gerentes. Squamae basi valde dilatatae, apicem versus longe attenuatae, acutae, brevissime aristatae, 2—3 mm. longae, extus glabrae, intus manifeste puberulae, pedunculo ipso sub squamulis fibroso-piloso. Spiculae 0,7—1,5 cm. longae et 2—3 mm. crassae, rhachide pilosae. Bracteae late ovatae, basi auriculatae, 2,5—3 mm. longae, apice breviter acuminatae, extus glabrae, intus pilosae, margine brevissime ciliatae, bracteolae lanceolatae, 1,5—1,8 mm. longae, dorso pilosae. Calycis lobi 4, superior late ellipticus laterales lineari-lanceolati, inferior profunde incisus, omnes 2 mm. longi, apice breviter acuminati et pilosi. Corolla non visa. Ovarium superum glabrum. Stylus filiformis, 0,5 mm. longus.

Holotypus: Alain 5073 SV!; Cuba; Prov. Oriente; in saxosis calcareis humidis rivi Rio Yumuri, prope opp. Baracoa. — Leg.: Alain, C. V. Morton et López Figueiras, 13. jan. 1956.

Elytraria filicaulis Borhidi et Muñiz sp. n.

Planta acaulis, radicibus brevibus fibrosis. Folia brevissime spathulata, lamina ipsa orbicularis vel late obovata, apice rotundata, basi breviter attenuata, 0,5—1 cm. longa et 0,4—0,8 mm. lata, in petiolum 1—1,5 mm late alatum, 0,5—1 cm. longum protracta; nervo medio utrinque prominulo et sparse ferrugineo-piloso vel glabrescenti, lateralibus utroque latere 2—3, arcuatis, utrinque prominulis et supra obsolete reticulatis, lamina supra viridis et papillosa, subtus opaca, margine integra, papyracea. Pedunculi filiformes, usque ad 6—7 cm. longi et 0,4—0,7 mm. lati, sub squamis glaberrimi. Squamuli e basi late ovati, auriculato-amplexicauli, longe attenuati, 1,5—2 mm. longi, extus glabri, intus superne minutissime lepidoti, inferne pilosiusculi. Spiculae solitariae, 2—6 mm. longae, usque ad 3 mm. latae, rhachide glabrae. Bracteae late ovatae, 2—2,5 mm. longae, acutae, brevissime aristulatae, inferne margine membranaceae et glabrae, superne brevissime ciliatae, extus glabrae, intus

lepidotae et pulverulentae. Bracteae 2, lanceolatae, 2 mm. longae, latitudine inaequimagnae, acutae, carinatae, dorso brevissime pilosae. Calycis lobi scariosi, superior lateralesque late ovati, laterales 2, dorso carinati et apice breviter aristulati, lobus inferior lineari-lanceolatus, apice bilobatus, omnes superne pilosi, 1,8—2 mm. longi. Capsula 2 mm. longa, glabra.

Holotypus: CLEMENTE 4736 SV!; Cuba; Prov. Oriente; Región de Moa. Orillas de un arroyo, charrascal del Coco. — Leg.: CLEMENTE, LEÓN, ALAIN et CRISÓGONE, 3. aug. 1945. — Isotypus: LEÓN 22618 SV!

Obs.: Cum praecedenti, foliis spathulatis, floribus calyceque 4-meris inter omnes species cubanas insignes. *E. filicaulis* ab *E. spathulifolia* pedunculis et rhachidibus glabris, lobis calycis lateralibus ovatis, carinatis et breviter aristatis, lobo inferiori bilobato omnino differt.

3. Stenandrium heterotrichum Borhidi sp. n.

Planta acaulis, 5—10 cm. alta; rhizoma usque ad 4 mm. crassum, radiculas multas filiformes emittens. Folia basalia 2—5 cm. longe petiolata, petiolis pilis longis albis tenuibusque puberulis vel glabrescentibus suffulta, obovata vel oblongo-obovata, basi longe acuminata, apice rotundata, 2—5,5 cm. longa et 0,8—1,8 cm. lata, supra pilis longis articulatis sparse et pilis brevissimis dense pilosa, subtus ad nervos longe pilosa, inter nervos brevissime hirtula, postremo glabrescentia et minutissime nigro-punctata, margine plana, integra vel manifeste crenulata, subchartacea. Inflorescentia folia superans, pedunculi 4—7 cm. longi, 1—1,5 mm. crassi, longe pilosi. Bracteae oblongo-obovatae vel lineari-obovatae, 6—10 mm. longae et 1,5—3 mm. latae, apice obtusae vel rotundatae, basi cuneatae, longe pilosae. Bracteolae 2, lineares, 2 mm. longae. Calycis lobi 5, lineari-lanceolati, subulati, 2,5—3 mm. longi, subaequimagni, basi in 1/4 altit. coaliti, dense pilosi. Corolla alba, tubo 4—5 mm. longo et 1 mm. lato, lobis breviter obovatis. Stamina in tubo corollino sub garganta inserta. Capsula 4,5—5 mm. longa, puberula. Semina 2, orbicularia vel obovata, marginem versus squamulosa.

Holotypus: UO 586 SV!; Cuba; Prov. Oriente; Playa Aguacate cerca de Maravi, O. de Baracoa. Leg.: LÓPEZ FIGUEIRAS 10. apr. 1960.

Obs.: *S. crenato* Urb. affinis a quo statura multo majore, indumento heteromorpho praeter alias notas species nostra clare differt.

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SUPRAINDIVIDUAL VERSUS INDIVIDUAL HOMOGENEITY OF PHOTOSYNTHETIC PIGMENTS: A STUDY ON COMMUNITY STRUCTURE*

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The photosynthetic pigment contents (chlorophylls and carotenoids) were examined in 3 strata of *Quercetum petraeae-cerris* association. The separation of the pigments was carried out by means of thin-layer chromatography. Besides the species (individual) samples, supraindividual, mixed samples, which contain the layer-forming species together, were also analysed in to determine whether there is such a regulation — operating at a supraindividual level — which has a homogenizing effect on the biochemical structure. Sampling of both the species-individuals and the supraindividuals was repeated four times, their evaluation is based on the scattering on the resemblance of the related repetitions and on the homogeneity of their diversity (pigment diversity).

On the basis of the standard deviation in the total chlorophyll content of the mixed samples, the shrub and herb layers are more homogeneous than their components the species, while the upper canopy takes a medium position between the two oak species (their components). The Euclidean distances (chord distances) calculated on the basis of the relative frequencies of the six pigments (chlorophyll-a, chlorophyll-b, carotene, lutein and antheraxanthin together, violaxanthin, neoxanthin) show that the upper canopy and the herb layer as a supraindividual unit is more homogeneous than the individual components. In the pigment diversity (expressed by means of SHANNON's formula) is considered, all the three layers are more homogeneous than the individual species. The fixed state of the pigment structure of the upper and lower layers of the forest, but especially that of the herb layer, indicates the existence of homeostasis regulated supraindividually.

Introduction

It is not accidental that today, when the function of the ecosystem is one of the outstanding questions of ecology, the structure of plant associations has become accentuated. Structure is a spatial order of certain elements, components. The principle of structural simultaneity defined by JUHÁSZ-NAGY must be accepted; according to that principle, in any of the objectums of the vegetation, there exist not only one but several and various structures simultaneously. For example, a structure may manifest itself in the real, topographical or in the topological space, it can be autophenetic or synphenetic (JUHÁSZ-NAGY 1972). For example, the synphenetic structural characteristic of the association is the species diversity which has recently been analysed on a very large scale, and often in connexion with its function.

* "Síkfőkút project" No. 33.

With respect to function, an essential synphenetic structure is the physiognomical structure of the community. Such is, for example, simply the vertical stratification, or the pattern of horizontal distribution of the leaves and the organs of the assimilation (which is in direct relationship with the leaf-area-index, LAI) also important with respect to function; the architecture taking into consideration also the vertical and horizontal arrangement, the inclination and orientation of the organs, is more complex (for review see FEKETE 1972). The models aimed at describing these structures, the so-called productive structures (MONSI—SAEKI 1953, MONSI 1968, etc.) form the basis of several other, community-photosynthesis models describing the primary function of primary producents, that is the CO_2 assimilation.

In close correlation with the light conditions, there exist photosynthetic pigment structures as well. ODUM—McCONNELL—ABBOTT (1958) were the first to describe the types of plant associations according to their pigment structure (vertical distribution of the chlorophyll concentration), and at the same time according to the efficiency of chlorophyll content, and to the energetic efficiency of photosynthesis. According to them there can be distinguished: 1) stratified communities (forest and benthic communities), 2. shaded communities (cave communities), 3. mixing communities (in turbulent upper waters), 4. thin cultures with all bright light (many laboratory cultures, in nature where only thin vegetation can develop on surface of rocks, water or in new colonization). Other authors, later even pointed out that in associations with well developed canopy (where edaphic factors — for example, water deficiency — do not prevent the closing of the foliage), with an adequate light dispersiveness of there is a reliable vertical connexion between the chlorophyll content of the various strata of the community and the logarithm of the light absorbed by the chlorophylls (cf. for example OKUBO—OIZUMI—HOSHINO—NISHIMURA 1968). BROUGHAM (1958, 1960, 1965, PILÁT 1967, OKUBO—KAWANABE—HOSHINO 1971) and others even pointed out that there is a correlation between the quantity of the chlorophylls (the so-called chlorophyll index, which is analogous with the LAI, cf. KVĚT—ONDOK—NEČAS—JARVIS 1971) and the growth rates in this cases. Recently, MALL—DAS (1974) pointed out a significant connexion between the chlorophyll content of the community and the standing biomass, while SING-BILLORE (1975) established a significant correlation between chlorophyll content and the energy content of the community. These connexions prove the existence and functioning of well-defined vertical pigment structures — as simultaneous, productive structures.

The simultaneous existence of several productive structures may raise the question which of them should be analysed? Evidently this considerations entails professional deliberation. In an environment with low radiation, for example, when the majority of the leaf mass is under the effect of low light intensity, the photosynthesis is to a great extent limited by light and photo-

chemical reactions. In these cases, it is reasonable for us to choose the photosynthetic pigments as a basis for comparison of photosynthesis; naturally, the pigment structure also becomes essential. HODÁNOVA (1973, 1975), for example, was able to describe the PhAR-attenuation in sugar-beet canopy better by means of the chlorophyll structure than by the leaf area structure. If on the other hand the majority of the assimilating organs live in an environment with high radiation then it is mostly CO_2, and the various (physical-anatomical) resistances related to its uptake, that play the part of limiting in such cases, a more suitable basis for comparison is provided by leaf area, and it is the structure formed by the assimilating organs that should be analysed.

GESSNER (1949) was the first to call attention to the fact that the various (aquatic) plant associations, with respect to their chlorophyll content, are rather uniform. The fact that there exists a much greater agreement between the chlorophyll contents of the various plant communities (calculated for a unit of area) than there is between the various species is considered by ODUM (1959) as a manifestation of the association homeostasis, "where the whole is not only different from, but cannot be explained by, the parts alone. In intact communities, various plants, young and old, sunlit and shaded, are apparently integrated and adjust, as fully as local limiting factors allow, to the incoming sun energy, which, of course, impinges on the ecosystem on a 'square meter' basis".

It is beyond doubt that the recognition of the above facts by GESSNER and ODUM has many perspectives even today. At the same time numerous methodological questions (for example, that of sampling) and more general questions of principle are awaiting clarification too. Evidently, the comparison of the pigment content of "communities in general" with that of the "species in general" is not enough. It is obvious that the discussion becomes more exact if we compare supraindividual and individual organizations within one community. This is what has been done in our study. We undertook the task of analysing the pigment structure according to strata in the stand of a multi-layered association. It should be noted here that in examining within the layers the distribution of the pigments in relation to one another, our analysis refers at the same time to a sort of — biochemical — structure. As regards this structure, we held the view that since the photosynthesis only takes place in the presence of all the pigment assemblage, therefore, not only the chlorophylls but also the carotenoids may be considered as part of this structure. (Evidently, similar views were held by for example VYAS—VYAS 1975 when they analysed, besides the chlorophylls, also the various carotenoid components; similarly, according to canopy strata — but only on individual levels.) We believe that the definiteness of this biochemical structure, and the certain constancy of its parameters (concerning both time and space) must be necessary

requirements for the values of the parameters of the material and the energy flow to remain nearly constant too.

If it can be demonstrated at a supraindividual level that the above-mentioned regulation of the pigment concentrations and pigment ratios which, even though different by species and by individuals, have incidentally come about at individual levels, this may mean that there is a kind of homeostasis in the photosynthetic system of the community. It must be emphasized, however, that even if the existence of such a homoestasis is pointed out it can by no means be an adequate study of homeostasis, it only may introduce it. The analysis of homeostasis is impossible without repetitions in time; the homeostatic mechanisms, which are responsible for the equilibrium, function in time; so do the various feedback control mechanisms (cf. Rosen 1967).

Let us mention here that the detailed description of the complete—vertical—pigment structure of the multi-layered forest will be given in another study (Tuba, 1977).

Material and method

Our examinations were carried out at Síkfőkút (Northern Hungary, at the foot of the Bükk Mountain, 6 km from the town of Eger), in the model area of the "Síkfőkút Project" (*Quercetum petraeae-cerris* ecosystem research) directed by the Botany Department of the Kossuth L. University of Debrecen. The present study contains the autumn data of the 1976 vegetation year. The examined forest is about 70 years old, of sprout origin. The qualitative description of the structure—first of all on the basis of projective covers—is given in the the paper by Jakucs—Horváth—Kárász (1975). According to the paper, the canopy layer is formed by two oaks (the name-giving *Quercus petraea*, *Qu. cerris*). The tree heights are in general between 15—19 m. The upper canopy covers 0.799 ha/ha; the trees do not or hardly integrate (average tree cover × number of individuals; 0.9414 ha/ha). The shrub layer separates into two layers: high and low shrub layers; these consist of 12 and 16 mainly common species. The upper shrub layer is of 1—5 m height, the most frequent in it is *Cornus mas* and *Acer campestre*. The lower shrub layer is below 1 m in it the most frequent is *Ligustrum vulgare*. The projective cover of the upper shrub layer is 0.6640 ha/ha, while that of the lower shrub layer is half of it, 0.3028 ha/ha. The individuals of the upper shrub layer are more integrating than those of the trees; multiplying the canopy cover of an average shrub by the number of individuals results in greater cover values (1.3081 ha/ha) than in the case of the canopy. Shrubs primarily lie not immediately below the trees but they fill the intervals between the trees, instead. The LAI of the forest is 8 ha/ha (± 10%) (Jakucs ex verb.).

In accordance with our aim, sampling was carried out in two ways: from the dominant species forming the layer (individual level), and from the mixed samples (supraindividual level). The dominant species examined were as follows: Canopy layer: *Quercus cerris*, *Qu. petraea*. Shrub layer: *Acer tataricum*, *Cornus mas*, *Euonymus verrucosus*, *Ligustrum vulgare*. Herb level: *Carex montana*, *Melica uniflora*. Three specimens were chosen from the species each. Samples were taken from the upper, middle and lower of all the individual specimens; representing in this way the various levels in the samples in their full heights. A further variation of sampling was that samples were taken also within the vertical "small layers" (for example, middle canopy layer), from parts more exposed to light or more shaded. In the case of herbs the upper, middle and lower vertical "small layer" means those parts of the plant itself. On the basis of the viewpoints mentioned before, 80 leaves were collected per species in the morning hours and the leaves were immediately processed. One disc per leaf was taken for the pigment examinations, with a cork-crew of 0.9 cm diameter. The pigment investigation took place in four repetitions per species, and from 20 discs per repetition. The "half-leaf"

method was used for taking the disc (MARÓTI—SZAJKÓ, 1972), and for that matter the middle part of the "half-leaf" since the distribution of the pigments changes from the base of the leaf towards the apex. The leaf ribs do not contain pigments, therefore, we mostly worked with symmetric leaves so that an identical quantity of leaf ribs could get into the various samples. From the herbs which could not be used in discs, leaf-pieces of 1—1.5 cm area were taken equivalent to about a circle of 0.9 cm in diameter.

For the mixed samples, the following method was elaborated. Sampling areas of 1 × 1 m in the herb layer, 6 × 6 × 2 m in the shrub layer, and 7 × 7 × 10 m in the canopy were marked (on the basis of reasonability and practicability considerations). It is important that the individuals of the species marked for the investigations in the individual level had to be marked within the sampling areas of the layers concerned so that they formed an organic part of that. For the supraindividual pigment investigations, leaf samples were taken from all the species occuring in the sampling area, in proportion to their percentage cover; in 20 discs of a repetition, the various species had to have so much share (taking a disc by leaf) that this figure should express the above ratio. The 20 discs collected in this way were crushed and the pigment extract of the supraindividual samples were prepared. This again was repeated four times.

The herb layer sample consisted of 11 species (*Carex montana, Melica uniflora, Fragaria vesca, Lathyrus vernus, Heracleum sphondylium, Galium schultesii, Dactylis polygama, Festuca heterophylla, Quercus petraea* juv., *Ligustrum vulgare* juv., *Cornus mas* juv.), so did the shrub layer sample (*Cornus mas, Cornus sanguinea, Euonymus verrucosus, Eu. europaeus, Acer tataricum, A. campestre, Crataegus monogyna, Cerasus avium, Clematis vitalba, Quercus cerris, Qu. petraea*), while the canopy layer consisted of two species (*Quercus cerris* and *Qu. petraea*).

The fresh and the dry weights of the leaf discs and of the herb leaf specimens were measured in all cases. The areas of the latter were measured with electronic light-planimeter (CZELLÁR—PAPP, B. 1975).

The extraction and the separation of various pigments were carried out according to the method of MARÓTI—GABNAI (1971), that is with thin-layer chromatography. The pigment quantities related to 1 g dry weight were calculated from the measured extinctions by means of the equation of HAGER—MEYER—BERTENRATH (1966).

In the samples analysed by means of the above method, each of the repetitions is characterized by the quantitative spectrum of the six pigments. The repetitions which belonged together — 4 in each of the cases — were compared in pairs to determine their similarity. The Euclidean distance, calculated on the basis of the normalized vectors, that is the chord distance was used, which, between repetitions j and k is

$$c(j, k) = [2(1-q_{jk})/\sqrt{(q_{jj} \cdot q_{kk})}]^{1/2}$$

$$\text{where } q_{jk} = \sum_h x_{hj} \cdot x_{hk};$$

$$q_{jj} = \sum_h x^2_{hj} \quad \text{and} \quad q_{kk} = \sum_h x^2_{hk};$$

here, $h = 1, \ldots 6$, the various pigments and x_{hj} the concentration of pigment h, in repetition j (ORLÓCI 1967).

The pigment spectra of the various repetitions were analysed also by means of the SHANNON—WEAVER's formula of information theory;

$$H' = -\sum_h p_i \log_2 p_i,$$

an index, sensitive to the relative ratios of the various components, which has gained ground in ecology and which is suitable for measuring the diversity in the characteristics we are concerned with. Here we estimate p_i by means of the relative concentrations of the individual pigment components determined in one repetition.

Results and discussion

Chlorophylls

First the homogeneity of chlorophylls will be examined because of their central role in the mechanism of photosynthesis. For this we use the values of standard deviation (Table 2) calculated from the chlorophyll concentrations of the repetitions, in mg/g (for their average values see Table 1).

In the canopy layer, the standard deviations of the chlorophyll components of the mixed samples, and of the quantity of total chlorophyll content, take a medium position between the corresponding values of the two oak species, on the basis of the four repetitions. The canopy layer itself, nevertheless, reflects a rather stable pigment layer, in comparison with the two lower layers.

In the shrub layer, the levels of both the chlorophyll-a and the total chlorophyll of the mixed samples are well adjusted. However, the standard deviations of chlorophyll-b, in the case of *Acer tataricum* and *Euonymus verrucosus*, remain below the values of the mixed samples taken from the shrub layers.

The herb layer is definitely homogeneous supraindividually, considering its chlorophyll concentration in comparison with that of the species. The standard deviation values of the layer forming species in the canopy layer are smaller than those in the shrub layer or herb layer. The cause of this can be found in the fact that the light conditions in the canopy layer are more uniform than those in the lower layers, where they are more extreme. As a result, chlorophyll homogeneity in the two lower layers manifests itself relatively more strongly at the supraindividual levels. Presumably, it is a kind of compensation for the fluctuation in light.

Chlorophylls and carotenoids

Besides the two chlorophylls, the following pigments were determined by means of the thin-layer chromatograph: carotene, lutein and antheraxanthin together, violaxanthin, and neoxanthin (Table 3).

By the Euclidean distances (chord distance, cf. Table 4) the homogeneity of the samples was estimated as follows; the smaller the distance, the greater the resemblance, that is homogeneity.

In a comparison between the species of the three layers, the two species of the canopy layer excell with respect to the well-fixed pigment structure having only slight deviations in their repetitions. In the shrub layer, *Ligustrum* (having leaves up to late winter time), which is ever-green in nature, is the most uniform, and again the pigment structure of *Acer tataricum* is the most variable. It should be noted that the band in which *Ligustrum* develops its

Table 1

Chlorophyll concentration in dominant species and in mixed samples of various strata of forest studied, 1976. (Averages of 4 repetitions)

	Chlorophyll a	Chlorophyll b	Chlorophyll a + b
	mg/g		
Upper canopy:			
Quercus cerris	0.979	0.297	1.276
Quercus petraea	1.214	0.591	1.806
Mixed sample	1.196	0.393	1.589
Shrub layer:			
Acer tataricum	0.621	0.624	1.245
Cornus mas	0.344	0.688	1.032
Euonymus verrucosus	1.185	1.669	2.827
Ligustrum vulgare	3.171	4.313	7.484
Mixed sample	0.335	0.704	1.040
Herb layer:			
Carex montana	3.687	2.336	6.023
Melica uniflora	5.693	3.431	9.124
Mixed sample	3.309	1.167	4.476

Table 2

Concentrations of carotenoids in dominant species and in mixed samples of various strata of forest studied, 1976. (Average of 4 repetitions)

	Carotene	Lutein + antheraxanthin	Violaxanthin	Neoxanthin
	mg/g			
Upper canopy:				
Quercus cerris	0.210	0.274	0.049	0.063
Quercus petraea	0.241	0.319	0.161	0.121
Mixed sample	0.272	0.300	0.122	0.086
Shrub layer:				
Acer tataricum	0.468	0.479	0.234	0.243
Cornus mas	0.325	0.560	0.228	0.145
Euonymus verrucosus	0.684	0.887	0.396	0.424
Ligustrum vulgare	0.224	0.563	0.550	0.270
Mixed sample	0.647	0.451	0.501	0.287
Herb layer:				
Carex montana	0.964	1.245	0.834	0.558
Melica uniflora	1.545	2.176	0.852	0.975
Mixed sample	0.283	0.551	0.403	0.256

Table 3

Standard deviations of values of chlorophyll concentrations

	Chlorophyll a	Chlorophyll b	Chlorophyll a + b
Upper canopy:			
Quercus cerris	0.102	0.010	0.096
Quercus petraea	0.167	0.224	0.284
Mixed sample	0.156	0.172	0.196
Shrub layer:			
Acer tataricum	0.291	0.075	0.259
Cornus mas	0.263	0.195	0.433
Euonymus verrucosus	0.396	0.091	0.460
Ligustrum vulgare	0.416	0.824	1.066
Mixed sample	0.089	0.189	0.226
Herb layer:			
Carex montana	2.963	1.386	4.339
Melica uniflora	2.496	0.980	2.188
Mixed sample	0.732	0.274	0.914

Table 4

The average values of chord distances between the repetitions of various (individual, supraindividual) samples. (Averages of 6–6 pair-wise comparisons)

Upper canopy:	
Quercus cerris	0.1050
Quercus petraea	0.1970
Mixed sample	0.0981
Shrub layer:	
Acer tataricum	0.4535
Cornus mas	0.2607
Euonymus verrucosus	0.3315
Ligustrum vulgare	0.1398
Mixed sample	0.5624
Herb layer:	
Carex montana	0.3044
Melica uniflora	0.3829
Mixed sample	0.1335

canopy is much narrower (lower shrub layer) then that of the 1—5 m high *Acer tataricum*, and that the light environment of the former is most probably more uniform.

Considering the pigment homogeneity of the mixed sample of the canopy layer, it surpasses even that of *Quercus cerris*, even though this is very homogeneous.

Not the same can be said of the shrub layer. In the lowest layer, a kind of definite uniformity re-establishes itself; the repetitions of the mixed sample are very similar to each other, the distance is more than double, even in *Carex montana*, of the mixed sample (Table 4).

The values of pigment diversity move in a rather well-definable interval (Table 5); it is only the low diversity value of *Ligustrum* that is conspicuous; it is explainable by the extremely high chlorophyll contents. On the basis of the standard deviations of pigment diversities (Table 6) a definite uniformity can be established in all three layers of the community. The standard deviation values of pigment diversity in the supraindividual samples are smaller in each of the layers than those of the species forming the layer. In comparison with the components (species), the pigment diversity of the herb layer is the most stable. It can be stated that the relative abundancies of the six pigments, with the standard deviations of their diversity values between 0.034 and 0.182, reflect a more stable situation than do the chlorophylls with their standard deviation values between 0.010 and 4.339. In the case of the total pigments

Table 5

The values of pigment diversity. (Averages of 4 repetitions)

Upper canopy:	
Quercus cerris	1.964
Quercus petraea	2.108
Mixed sample	2.033
Shrub layer:	
Acer tataricum	2.410
Cornus mas	2.374
Euonymus verrucosus	2.349
Ligustrum vulgare	1.807
Mixed sample	2.396
Herb layer:	
Carex montana	2.315
Melica uniflora	2.221
Mixed sample	1.896

Table 6

Standard deviations of values of pigment diversity

Upper canopy:	
Quercus cerris	0.102
Quercus petraea	0.053
Mixed sample	0.043
Shrub layer:	
Acer tataricum	0.135
Cornus mas	0.077
Euonymus verrucosus	0.074
Ligustrum vulgare	0.118
Mixed sample	0.056
Herb layer:	
Carex montana	0.182
Melica uniflora	0.135
Mixed sample	0.046

also, the level of the pigments in the canopy stratum is more definite, in comparison with those of the two lower layers.

If therefore we do not accentuate the individual components — as is done in the case of the chord distance — and consider only the changes in pigment distribution, then the homogeneity can be detected in all the three strata, that is in the shrub layer as well. The greater homogeneity of the supra-individual samples, in comparison with the individual ones, in the canopy and the herb layer, was caused by the nearly identical ratios of the six components. The cause of similarity is identical with that of the diversity values. For the time being, it is difficult to explain the increased homogeneity the supraindividual pigment diversity in the shrub layer; in the four repetitions of the supraindividual samples, the pigment ratios are different, which results in a relatively high average distance, while at the same time the diversity values continue to remain at nearly identical levels. It would bring us nearer to the solution of the question if we knew the species diversity structure of the community and its layers; MARGALEF, for example, considers that the species diversity and certain — supraindividual — biochemical diversities (according to him simply the carotenoid-chlorophyll ratio) are correlated. So far very few investigations have been carried out in this line, with respect to terrestrial communities almost nothing has happened. An exception is the

* It is important to note that even though we in principle agree with the importance of the carotenoid/chlorophyll ratio, the D_{430}/D_{665} ratio (D = optical density) recommended by MARGALEF, cannot be accepted for the estimation of diversities, for reasons mentioned by WINNER (1972) and also because of other objections.

phytoplankton which is methodically easier to be analysed (MARGALEF 1958, 1963, 1964, 1965; ANTIA et al. 1963, WINNER 1969, HALLEGRAEFF 1976a, b) and the laboratory microcosmos (COOKE 1967). For the expression of the changes in community structure (which ensues under the effect of the changes in light conditions of the phytoplankton), MCINTIRE—TINSLEY—LOWRY, 1969, consider the diversity of fatty acids more suitable than pigment diversity. ODUM's article (1969), which is so often quoted, also calls attention to such biochemical diversities.

Let us note here that the carotenoid/chlorophyll ratio shows the same pattern as the chord distances; the supraindividual sample is more uniform, in the uppermost and lowermost layers, than are the individual samples, whereas this does not refer to those in the shrub layer.

From our results we can infer that there exists such a regulation at the supraindividual level which homogenizes — in accordance with the conditions and requirements of the community organization — the pigment structure built up on the individual levels. It is plausible that in the levels organized from many species and treated uniformly by the environment — where the whole scale of light-adapted leaves and shade-adapted leaves of all the species present — with all their transitions — are present by a thoroughly "designed" ratio, — the relative ratios of the various pigments are of a more precisely fixed value than the ones belonging to the various species. However, the layers of the multi-layered community do not — in many respects — behave identically. It seems that the lowest layer of the forest, the herb layer is that where the homogenizing effect of the supraindividual organization is the strongest. One probable reason for this is to be found in the reaction of the pigment systems which are sensitive near the light minimum. On the other hand, it is possible that the herb layer, having many species, tolerates the daily strong light-fluctuation in this way. From the viewpoints of sampling also, the herb level is a more favourable objectum: it is composed of many species, more compact than the diffuse shrub layer which is difficult to be sampled. The stableness of the pigment structure of the forest-herb layer (but, if not so definitely, that of the canopy layer) indicates the presence of homeostasis regulated supraindividually. The important details of this need to be clarified by planning suitable time-dynamic investigations (delimitation of the period of homogeneity greater at supraindividual than at individual level etc.), and by a causal analysis of the regulation mechanism.

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ALGAL SPECIES DIVERSITY IN TWO EUTROPHIC FISHPONDS

PART II. OTHER THAN SPECIES-INDIVIDUAL LEVELS

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Our diversity programme run by means of a set of hypothetical data has confirmed that a great number of our indices are very sensitive to sample size, thus they are unsuitable for algological purposes. In our further researches, only H'', J and S will be used. The volumetric biomass of the various algal species will be given in the present study. Diversities calculated from the individual and from volume data correlated with each other in the non-fertilized fishpond, while in the fertilized one they did not. The latter phenomenon is due to the lower evenness and equitability (J and ε) — primarily to the salient data of the absolutely dominant species. The diversity computed from the volume data appears to lag behind its possible maximum even more than that experienced in the individual data; this tendency is more pronounced in the fertilized lake. The fishponds are rich in genera (2.3 infrageneric taxa fall to one genus, on average), therefore, the diversity on genus level did not significantly differ from that of the species. On division level, however, the loss of information is indeed significant. It was only the *Chlorophyta* division which was always quantitatively dominant, the species diversity of which correlated significantly with that of total algae.

In Part I of the series (HAJDU 1976), we examined the diversity in two fishponds on species-individual level. In Part II, we shall now examine some other diversity problems, *viz.:* sensitivity of the used indices to the sample size; correlations between diversities calculated on the basis of number of specimens per species and of volume per species; partition of the diversity to some taxonomic levels; relationship between the diversity of individual divisions and that of the total algaflora.

Methods

The quantitative plankton data serving as a basis for the article have already been given in an earlier publication (HAJDU 1974). When computing the diversity, we endeavoured to follow the usual symbols: H'' — SHANNON measure of diversity, H — BRILLOUIN measure of diversity, J — evenness, S — number of species, etc. Some other symbols have also been used; for example, evenness computed on the basis of the various equations is denoted J_1, J_2, J_3, J_4. It would have been too voluminous to repeat the equations here again, therefore, we only refer to the collection of equations furnished in Part One (HAJDU 1976).

When I carried out the quantitative count, I did not know yet that our image of the community structure would be dependent on sample size. If we increase the sample size (by counting more individuals under the inverted microscope), then the number of species increases, while the evenness decreases continually.

Part of the changes occurring in the diversity as a result of the above phenomenon is due to counting artifacts, but the range of changes is considerably wider than the one caused by this error.

There are two ways of avoiding the above error, *viz.* by using standard sample sizes, or by PIELOU's subsamplinganalysis. If we consistently count in each sample for example 1000 algal individuals, then the proportion between the overestimation of the common species and the underestimation of the rare species will decrease considerably. PIELOU's method requires essentially more work than this (PIELOU 1966, 1975; LLOYD, INGER, KING 1968). We have to increase the sample size (N) continually, than diversity (H'') is to be plotted as

a function of sample size. Initially, H'' rapidly increases because of new species entering the process, but later on, new species are ever more seldom to be found. It is about at this stage that H'' has its maximum, and from now on it decreases. This is so because evenness (J) decreases; disproportionately more of the dominant species can be detected; it is easier to find new rare species than new individuals belonging to the recorded rare species.

In some samples, we carried out PIELOU's analysis afterwards, and we found that, by counting up to 700—1500 ind/sample total algal number (N), we were already at the declining branch of the diversity curve. As far as I know, no such analysis has as yet been carried out in algae. Since in the technicalities of our method there is some deviation from that of PIELOU, we think it is worthwhile to describe ours briefly. When counting by means of the inverted microscope, each of the individuals is recorded on the counting sheet with a small dash in the row of the given species, as is usual. A mere change in comparison with the traditional method is that the counting carried out and recorded with respect to a visual area of the eutrophic water is closed by a bar in relation to about each of the visual areas, while on the right-hand side of the bar we write the cumulative number of the individuals (it is the sum total of the number of individuals observed in the given species examined up to that time). From the more longer series of the cumulative numbers (the species list increases), which consists of increasingly greater figures, diversity is computed again and again. Then we continue counting, but the recording bars are now written on the right-hand side of the last row of figures. After scrutinizing the visual areas, we close the sheet again and compute the diversity again. The highest H'' value is accepted as characteristic of the community. A great help in our work can be a programmable pocket calculator; while sitting by the microscope, we can complete the mass of diversity calculations within a few minutes. Labour-consuming microscopical counting can be spared in this way, since as soon as diversity turns into persistent decline, we can stop counting. Using a larger computer for this purpose would be rather time-consuming. A larger computer is needed indeed only if further data-processing (classification, ordination, etc.) is planned. A programme prepared for Texas SR 56 calculators is available on request.

Dr. P. JUHÁSZ-NAGY has been so kind as to call my attention to the fact that computing the arithmetic mean, and BRAVAIS's estimation of the correlation between these indices, from diversity values from the ingredients of diversity is not without problems. The cause of this has already been stated by LLOYD and GHELARDI (1964): "However, since both $H(s)$ and $M(s)$ are on a scale of 'bits of information per individual', *something akin to a logarithmic scale*, it does not seem appropriate to compare them by means of a ratio." (Italics by the author.) By taking the average of values on a logarithmic scale, we underestimate the real mean; probably, the mode is more appropriate to be used, instead. In the few cases I have examined, mean and mode were fairly near to each other; the error does not seem too considerable. The mean is nevertheless appropriate for providing information in the case for example, of evaluating a histogram. In the present work we did not take the averages from the indices in the tables. In the literature, however, the averaging of the diversity values is frequently described; for example, in MACARTHUR (1965), PIELOU (1966), LLOYD (1968), GOLDMAN (1970), EGLOFF—BRAKEL (1973), MOSS (1973). Calculation of linear correlations is allowable only in the case of measured, normally distributed data, but, in spite of this, it is often carried out (ELORANTA 1976, HAJDU 1976), or even if not calculated, the correlation diagram is published (for example, PIELOU 1966, H plotted versus J). In the present work, SPEARMAN's rank correlation (R) is used instead of BRAVAIS's correlation. Significance is denoted as follows: ∗ ∗ ∗ 0.1%, ∗ ∗ 1%, ∗ 5%, *N. S.*: non-significant.

For comparing the various diversities, here again the simplest method is used, i.e. the comparison of the values of indices. It we intended not merely to compare the differences in the complexity of the two structures, but at the same time we should like to consider also the similarity of species lists, this would require a more complicated method; for example to calculate H_{diff} (MACARTHUR 1965, MACARTHUR et al. 1966) or R_0 (HORN 1966) etc. Results of such of investigations will be given in the next article of the series.

We wanted to supplement the earlier diversity values calculated on the basis of individual species numbers ($H''_{indspec}$) with those calculated from biomass ($H''_{volspec}$). After microscopic measurements, algal models were prepared; while immersing the model in water the volume of algae was determined; in algae the form of which could be approximated by means of simple geometric bodies, the volume was determined by calculations. By taking the algal specific weight uniformly as 1.000, the volume was calculated for fresh weight where 1 mm^3 = = 10^9 μm^3 = 1 mg. The average yearly volume of the various species is given in Table 3. By multiplying the ind/cm^3 values of the earlier (HAJDU 1974) data matrix with the volume data one by one, then the matrix containing the volume data is obtained. This has served as a basis for $H''_{volspec}$ calculations.

Results

1. Sample size dependency of some indices in the algological practice

In the first article of this series (HAJDU 1976) it was stated that the values of some indices were in agreement up to two to four decimal places; if we consider also the variance then these values are practically identical (H with H'', J_{1-4}, R_{1-4}). This was attributed to the great number of algal individuals. The vol/cm^3 data were about ten times greater than the ind/cm^3 data, and then the agreements were even more pronounced. PIELOU (1975) wrote that

$$\lim_{\min (n_i) \to \infty} H = H'' \quad \text{and} \quad H'' - H > 0$$

It seemed however that the agreement is significant even in the n_i data occurring also in practice. In order to check this, the programme was run by means of a set of hypothetical data (Table 1). The results are given in Table 2.

Table 1

Eight artificial samples for testing the sample size dependence of the indices

No.	Number of individuals per species
1	6, 2, 1, 1
2	3, 2, 2, 2, 1
3	60, 20, 10, 10
4	80, 9, 5, 2, 1, 1, 1, 1
5	640, 152, 84, 59, 4, 4, 4, 4, 4, 4, 3, 3, 3, 3, 3, 3, 3, 3, 2, 2, 2, 2, 2, 1, 1, 1, 1, 1, 1, 1
6	210, 200, 200, 200, 190
7	6400, 2000, 1200, 310, 40, 20, 10, 8, 6, 2, 2, 1, 1
8	82346, 12468, 3312, 1214, 254, 123, 86, 82, 73, 12, 8, 7, 6, 2, 1, 1, 1, 1, 1, 1, 1

Table 2

Some characteristic indices obtained after the run of the first set of data. H'' and J_1 are mostly independent of sample size

No.	s	H''	var H''	H	J_1	J_2	J_3	J_4
1	4	1.5710	0.3129	1.1601	0.78548	0.33297	0.77134	2.2449
2	5	2.2465	0.4415	1.6530	0.96749	0.86300	0.96795	1.0868
3	4	1.5710	0.0299	1.4800	0.78548	0.75596	0.77873	0.74019
4	8	1.1649	0.0430	1.0413	0.38831	0.24717	0.37259	0.18024
5	30	1.9180	0.0077	1.8553	0.39087	0.34692	0.38671	0.33565
6	5	2.3212	0.0043	2.3018	0.99969	0.99969	0.99969	0.99968
7	13	1.4809	0.0003	1.4768	0.40019	0.39731	0.39986	0.39672
8	21	0.90984	0.0000	0.90916	0.20714	0.20649	0.20706	0.20636

Table 3

Average volume of the algal species to be found in the fishponds: μm^3/individual (no designation); μm^3/col. (with colony); μm^3/fil. (filamentous)

Algae	Volume, μm^3	Algae	Volume, μm^3
Achroonema macromeres Skuja/fil.	600	*P. pseudonordstedtii* Pochm.	2 800
Anabaena circinalis Rabh./fil.	1 500	*P. pyrum* (Ehr.) Stein	3 200
Anabaena flos-aquae (Lyngb.) Bréb./fil.	1 000	*Trachelomonas dybowskii* Drez.	2 500
Aphanizomenon issatschenkoi (Ussacz.) Pr. L./fil.	2 000	*T. planctonica* Swir.	2 500
Chroococcus turgidus (Kg.) Naeg./col.	3 000	*T. planctonica* var. *vermiculosa* Balech.	9 000
Gomphosphaeria lacustris Chod./col.	150	*T. scabra* Playf.	3 500
Lyngbya circumcreta G. S. West/fil.	200	*T. similis* Stokes	4 000
L. epiphytica Hieron./fil.	80	*T. verrucosa* var. *granulosa* (Playf.) Conr.	900
L. limnetica Lemm./fil.	240	*T. volvocina* Ehr.	500
Merismopedia marssonii Lemm./col.	400	*T. volvocinopsis* Swir.	1 500
M. tenuissima Lemm./col.	400	*Trachelomonas* sp.	2 000
Microcystis aeruginosa Kütz./col.	16 000	*Amphora ovalis* Kütz.	4 000
M. elachista f. *planctonica* G. M. Smith/col.	600	*Anomoeoneis sphaerophora* (Kütz.) Pfitz.	3 000
M. flos-aquae (Wittr.) Kirchn./col.	5 000	*Attheya zachariasi* J. Brun	2 200
M. marginata (Menegh.) Kütz./col.	100	*Bicoeca cristallina* Skuja	250
Oscillatoria limnetica Lemm./fil.	20	*B. ovata* Lemm.	400
O. pseudogeminata G. Schmid/fil.	3 000	*B. planctonica* Kissel	400
O. tenuis var. *tergestina* Rabenh./fil.	250	*Centritractus africanus* Fritsch et Rich	150
Pelonema subtilissima Skuja/fil.	16	*C. brunneus* Fott	120
Phormidium foveolarum (Montagne) Gomont./fil.	3 000	*Cercobodo varians* Skuja	270
		Chrysococcus guttaeformis Hortob.	1 000
P. mucicola Naum. et Huber—Pest./fil.	40	*Cocconeis placentula* var. *euglypta* (Ehr.) Cl.	650
Pseudanabaena articulata Skuja/fil.	6	*Cyclotella chaetoceras* Lemm.	5 600
P. catenata Lauterb./fil.	150	*Desmatractum indutum* (Geitl.) Pasch.	250
Rhabdoderma lineare var. *spirale* Wolosz./fil.	80	*Dinobryon divergens* Imhof	550
		Fragilaria crotonensis Kitt.	3 500
Romeria leopoliensis (Racib.) Koczw.	8	*Gloeobotrys coenococcoides* Fott	120
Spirulina laxa Smith	90	*Goniochloris mutica* (A. Braun) Fott	50
Synechocystis aquatilis Sauv.	50	*G. sculpta* Geitl.	60
Unknown *Cyanophyta*	15	*Gyrosigma attenuatum* (Kütz.) Rabenh.	8 600
Euglena acus Ehrb.	3 100	*Kephyrion littorale* Lund	40
E. acus var. *longissima* Defl.	21 600	*Khawkinea acutecaudata* Skuja	7 500
E. antefossa L. P. Johnson?	500	*Mallomonas acaroides* Perty	7 800
E. oxyuris f. *minima* Bourr.	2 200	*Mastigella* sp.	1 500
E. pisciformis Klebs.	650	*Melosira granulata* (Ehr.) Ralfs/fil.	3 500
E. polymorpha Dang.	5 300	*M. granulata* var. *angustissima* Müll./fil.	450
E. spathirhyncha Skuja	17 000		
E. tripteris (Duj.) Klebs	3 800	*M. granulata* var. *angustissima* f. *spiralis* Hust./fil.	600
E. viridis Ehr.	2 200		
Euglena sp.	9 000	*Monas vorax* Skuja	500
Lepocinclis cymbiformis Playf.	1 100	*Monosiga ovata* S. Kent	400
L. ovum var. *conica* Allorge et Lef.	1 600	*Multicilia lacustris* Lauterb.	3 000
Phacus acuminatus Stokes	3 500	*Navicula hungarica* var. *capitata* (Ehr.) Cl.	550
P. caudatus Hübn.	3 500		
P. caudatus var. *minor* Drez.	2 300	*Nitzschia acicularis* W. Smith	280
P. curvicauda Swir.	3 200	*N. palea* (Kütz.) W. Smith	380
P. granum Drez.	1 800	*Ophyocytium capitatum* Wolle	600
P. helicoides Pochm.	25 000	*O. cochleare* A. Braun	2 700
P. longicauda (Ehr.) Duj.	15 000	*Paraphysomonas vestita* (Stokes) De Saedeleer	3 000
P. orbicularis Hübn.	12 000		

Algae	Volume, μm^3
Pseudokephyrion entzii Conrad	75
Rhizosolenia longiseta Zach.	4 000
Salpingoeca amphoridium J. Clarc	550
Stephanodiscus hantzschii Grun.	1 200
Synedra acus Kütz.	800
S. ulna (Nitzsch.)	900
Synura petersenii Korschik.	2 000
Unknown epiphyte	400
Other *Centrales* (2 species)	200
Other *Pennales* sp. 1	300
Other *Pennales* sp. 2	100
Other *Pennales* sp. 3	100
Ceratium hirundinella (O. F. Müll.) Schrank	60 000
Cryptomonas pusilla Bachm.	60
Cryptomonas sp.	3 000
Gymnodinium sp.	4 500
Actinastrum hantzschii Lagerh./cen.	1 200
Ankistrodesmus acicularis (A. Br. Korschik.)	80
A. angustus Bern.	30
A. bibraianus (Reinsch.) Korschik.	300
A. convolutus Corda	10
A. falcatus (Corda) Ralfs	450
A. longissimus Lemm.	1 300
A. pseudomirabilis Korschik.	100
A. subcapitatus Korschik.	120
Carteria multifilis (Fres.) Dill.	600
C. peterhofiensis Kissel.	3 000
Chlamydomonas epiphytica G. M. Smith	250
C. globosa Snow	120
C. rodhei Skuja	2 500
C. skujae Pasch.	500
Chlamydomonas sp. 1	200
Chlamydomonas sp. 2	500
Chlamydomonas sp. 3	1 000
Chlorella vulgaris Beyer.	150
Chlorhormidium flaccidum (Kütz.)Fott	50 000
Chlorogonium elegans Playf.	750
C. elongatum Dang. var. *plurivacuolatum* Skuja	4 000
C. tetragamum Bohl.	190
Chodatella amphitricha Lagerh.	100
C. balatonica Scherff.	100
C. ciliata (Lagerh.) Lemm.	1 400
Chodatella sp.	200
Closterium limneticum var. *tenue* Ruzicka	580
Coelastrum microporum Naeg./cen.	6 000
C. sphaericum Naeg./cen.	6 000
Crucigenia quadrata Morren/cen.	120
C. rectangularis (A. Brau) Gay/cen.	60
C. tetrapedia (Kirchn.) W. et W./cen.	100
Dicellula inrmis Fott/cen.	130
Dictyosphaereium ehrenbergianum Naeg./col.	1 200
D. pulchellum Wood/col.	1 800
Elakatothrix lacustris Korsch.	160
Franceia tenuispina Korschik.	600
Gloeotaenium loitlesbergianum Hansg.	20 000
Hyaloraphidium contortum var. *tenuissimum* Korschik.	475
Kirchneriella lunaris (Kirch.) Moeb.	70
K. obesa (W. West) Schmidle	120
Koliella longiseta (Visch.) Hindák	500
Lagerheimia genevensis Chod.	150
L. marssonii Lemm.	250
Lobomonas ampla var. *okensis* Korschik.	550
Micractinium pusillum Fres./cen.	1 600
Mycacanthococcus cellaris Hansg.	400
Nephrochlamys subsolitaria (West) Korschik.	400
Oocystis elliptica f. *minor* W. West	900
O. lacustris Chod.	300
O. parva W. et G. S. West	200
O. submarina var. *variabilis* Skuja	150
Pandorina morum (Müller) Bory	8 000
Pediastrum boryanum (Turp.) Menegh./cen.	6 000
P. duplex Meyen./cen.	8 000
P. simplex (Meyen.) Lemm./cen.	5 000
P. tetras var. *tetraodon* (Corda) Rabenh./cen.	250
Phacotus lenticularis (E. Stein)	600
Pteromonas angulosa Lemm.	250
Scenedesmus acuminatus (Lagerh.) Chod./cen.	300
S. acuminatus f. *tortuosus* (Skuja) Uherkov./cen.	300
S. acutus Meyen/cen.	300
S. anomalus (G. M. Smith) Tiff./cen.	200
S. anomalus var. *acaudatus* Hortob./cen.	100
S. arcuatus Lemm./cen.	800
S. brevispina (G. M. Smith) Chod./cen.	400
S. coartatus Hortob./cen.	450
S. decorus Hortob. var./cen.	500
S. denticulatus var. *linearis* Hansg./cen.	550
S. dispar Bréb./cen.	1 200
S. dispar f. *spinosus* Hortob./cen.	900
S. ecornis (Ralfs) Chod./cen.	1 000
S. ecornis (Ralfs) Chod. forma/cen.	1 500
S. ecornis var. *disciformis* Chod./cen.	3 000
S. granulatus W. et G. S. West/cen.	1 000
S. granulatus f. *elegans* Hortob./cen.	1 000
S. granulatus f. *disciformis* Hortob./cen.	4 000
S. intermedius var. *bicaudatus* Hortob./cen.	1 000

Algae	Volume, μm^3	Algae	Volume, μm^3
S. lefevrii var. *semiserratus* Uherkov./cen.	800	*Schroederia spiralis* (Printz) Korschik.	1 000
S. lefevrii var. *semiserratus* Uherkov. forma/cen.	800	*Siderocelis minutissima* (Korschik.) Heynig	70
S. longispina var. *capricornus* Skuja/cen.	700	*S. oblonga* (Naum.) Fott	80
S. opoliensis P. Richt./cen.	1 200	*S. ornata* (Fott) Fott	140
S. ovalternus Chod./cen.	1 000	*Sphaerocystis schroeteri* Chod.	1 400
S. opoliensis var. *bicaudatus* Hortob./cen.	1 200	*Staurastrum contortum* G. M. Smith	300
S. protuberans Fritsch./cen.	550	*S. paradoxum* Meyen	500
S. quadricauda (Turp.) Bréb./cen.	1 000	*S. polymorphum* Bréb.	2 300
S. quadricauda var. *longispina* f. *asymmetricus* (Hort.) Uher	1 000	*Tetraedron caudatum* var. *incisum* Lagerh.	150
S. quadricauda var. *maximus* W. et G. S. West/cen.	4 500	*T. incus* var. *torsum* Turn.	500
S. quadricauda (Turp.) Bréb. varietas/cen.	900	*T. limneticum* Borge	1 000
S. rectus Hortob. et Németh varietas/cen.	600	*T. minimum* (A. Braun) Hansg.	1 000
S. semicristatus Uherkov./cen.	300	*T. minimum* var. *longispinum* Defl.	1 000
S. soói var. *symmetro-granulatus* Hortob./cen.	500	*T. triangulare* Korschik.	50
S. soói Hortob. varietas 1./cen.	3 000	*Tetrastrum glabrum* (Roll.) Ahlstr. et Tiff./cen.	150
S. soói Hortob. varietas 2./cen.	500	*T. pulloideum* Teiling/cen.	150
S. spinosus Chod./cen.	400	*T. punctatum* (Schmidle) Ahlstr. et Tiff./cen.	200
Scenedesmus sp./cen.	500	*T. staurogeniaeforme* (Schroed.) Lemm./cen.	250
		T. sp.	50
		Treubaria triappendiculata Bern.	1 000
		T. varia Tiff. et Ahlstr.	2 000

2. *Diversity on species-volume level*

The basic aim of the examinations was to determine the yearly course of diversity in the two fishponds, and to examine whether any differences occurred in the diversity of the fish ponds having different trophy. Several authors have already suggested (for example, WILHM 1968, LLOYD and GHELARDI 1964) that diversity should be calculated from volume or biomass data instead of the number of individuals because the differences in size will even out in this way. If biomass and not the number of individuals is taken as a measure of species "importance", then the yearly course of diversity takes a slightly different form. In Table 4, where the results are given, var H'' does not occur because it was zero to four decimal places; neither does H, because it was in agreement with H″, up to five decimal places.

In the fertilized fishpond, the biomass of the algae was always higher also in its totality, but the biomass of 100 thousand algae was greater too: 0.1432 mg, S. Dev. 0.1104, and again in the non-fertilized pond it was 0.1030 mg, S. Dev. 0.0915.

In order to estimate the similarity of indices calculated on the bases of volume and individuals the correlation was determined (Table 5). In the non-fertilized lake, the trends of diversity and of evenness to a great extent follow

the same course whether we start from ind./spec. or from vol./spec. data (Fig. 1). However, owing to the low evenness in the fertilized fish pond (there are a great number of algae with different volumes in one sample), there is no correlation between the diversities computed from the two kinds of data. The evenness trend closely follows the dominance trend $(p_i)_{\max} = \left(\frac{n_i}{N}\right) \max\%$; high dominance
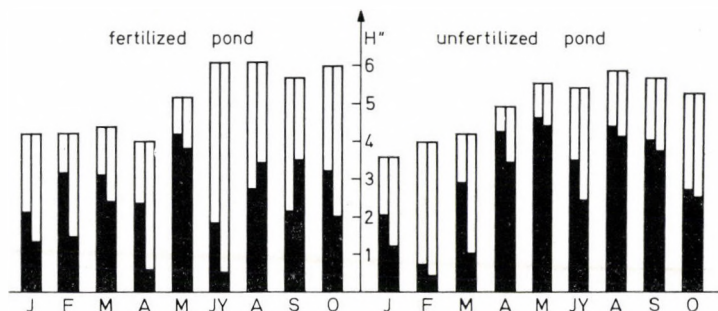
Fig. 1. Diversity maximum (empty column); diversity computed from the individual per species data (the black column drawn into the left-hand half of the empty column); and from the volume per species data (black column on the right-hand side). To the left of the vertical axis, the monthly data of the fertilized pond; to the right those of the non-fertilized pond. The diversity unit is bit/individual, or bit/μm^3

is accompanied by low evenness (Table 4). In the fertilized fishpond $R = 0.9333^{***}$, in the non-fertilized pond $R = 0.966^{***}$. Thus, the differences in the results obtained by means of the two methods occur mainly because of the difference in the only mostly dominant species. The LLOYD-GHELARDI measure of equitability gave similar values as the measure of evenness, its correlation is not significant in the fertilized fishpond, and again in the non-fertilized one the correlation of $\varepsilon_{\mathrm{vol}}$ and $\varepsilon_{\mathrm{ind}}$ is significant on a $p < 0.1\%$ level (Table 5).

The volume/species diversity values in the two fishponds are smaller than that of individual/species. Since the species numbers are in agreement, this decrease is only attributable exclusively to the lower evenness (more pronounced volume dominance). In two cases of the 18, $H''_{\mathrm{volspec}} > H''_{\mathrm{indspec}}$. This tendency was even more pronounced in the fertilized fish pond where H''_{volspec} appeared even more behind its possible maximum than in the case of H''_{indspec}.

The value of SPEARMAN's correlation between MARGALEF's index (M) and SHANNON's diversity computed from the volume data does not significantly differ from zero.

Table 4

Yearly changes in the indices computed on the basis of volume data obtained from the fishponds. G: algal fresh weight mg/l; S: species number of the sample; H″: Shannon diversity bit/μm³/species; J: evenness; M: Margalef index; $d = (n_i/N)_{max}$ %; ε: equitability

Month	G mg/l	S	H″	J	M	d%	ε
Fertilized, more eutroph fishpond							
J	2.470	18	1.3044	0.31280	2.1761	79.66	0.17
F	6.290	19	1.4777	0.34786	2.0579	78.22	0.19
M	13.743	21	2.3993	0.54624	2.0990	38.18	0.33
A	103.355	17	0.60681	0.14846	1.3858	92.71	0.12
M	22.384	36	3.8148	0.73788	3.4945	19.94	0.58
JY	876.918	72	0.48147	0.07804	5.1885	95.45	0.03
A	141.609	68	3.4698	0.56999	5.6488	22.07	0.23
S	170.065	53	3.5897	0.62670	4.4959	23.77	0.32
O	103.250	67	2.0924	0.34493	5.7170	72.20	0.07
Mean	160.009	41				58.02	
Unfertilized, less eutroph fishpond							
J	0.599	12	1.2449	0.34727	1.7201	81.60	0.25
F	0.026	16	0.37448	0.09362	4.6038	95.37	0.06
M	14.227	18	0.96506	0.23143	1.5686	85.41	0.11
A	4.980	30	3.4705	0.70727	3.4065	23.05	0.53
M	18.263	44	4.4034	0.80656	4.3821	11.00	0.73
JY	26.268	46	2.4196	0.43805	4.5859	58.42	0.15
A	9.238	61	4.1127	0.69346	6.5709	16.42	0.43
S	26.651	53	3.7601	0.65645	5.1028	38.52	0.38
O	65.697	39	2.5478	0.48200	3.4257	36.73	0.21
Mean	18.439	35				49.61	

Table 5

Spearman's rank correlation values computed on the basis of volume per species and number of individuals per species in the ponds

	Fertilized	Unfertilized
$H_{ind}-H_{vol}$	+0.4667 *N.S.*	+0.9000***
$J_{ind}-J_{vol}$	+0.4000 *N.S.*	+0.9000***
$d_{ind}-d_{vol}$	+0.4166 *N.S.*	+0.8500**
$\varepsilon_{ind}-\varepsilon_{vol}$	+0.5166 *N.S.*	+0.6666*

3. *The effect of pooling the data to a higher taxonomical level on the indices*

The species individual and volume data within genera and divisions were pooled (as if the determination had taken place only for *Scenedesmus* sp. or *Chlorophyta* sp. level), and from the data obtained in this way, the hierarchic diversity was computed. The results are given in Table 6. We did not

Table 6

Demonstration of the effect of pooling on the index. Cumulative hierarchical diversity and its ingredients. At diversity in the species column is $H''_{(DGS)}$, *in the genus column* $H''_{(D)} + H''_{(D)}(G)$, *in division column:* $H''_{(D)}$

		Month	Diversity			Evenness			Taxa/sample		
			species	genus	divisio	species	genus	divisio	species	genus	divisio
Individual data	fetrilized	J	2.1613	2.1422	1.4267	0.51830	0.53554	0.61445	18	16	5
		F	3.2329	3.0078	1.9178	0.76105	0.79000	0.82595	19	14	5
		M	3.1174	2.4103	1.3828	0.70970	0.58967	0.69138	21	17	4
		A	2.2980	2.2980	0.64703	0.56220	0.56220	0.27866	17	17	5
		M	4.2057	3.7230	1.4295	0.81349	0.75872	0.61564	36	30	5
		JY	1.7994	1.4898	0.21547	0.29165	0.27807	0.09280	72	41	5
		A	2.6742	2.5608	1.1262	0.43929	0.47798	0.48505	68	41	5
		S	2.1272	2.0291	0.69144	0.37137	0.40224	0.29779	53	33	5
		O	3.2066	3.0271	1.3410	0.52861	0.59500	0.57753	67	34	5
	unfertilized	J	2.0294	1.9284	1.4362	0.56610	0.55744	0.61853	12	11	5
		F	0.7867	0.78554	0.65090	0.19667	0.20632	0.28033	16	14	5
		M	2.9472	2.9449	1.6928	0.70676	0.72047	0.84638	18	17	4
		A	4.3587	4.1210	1.4834	0.88828	0.91100	0.74171	30	23	4
		M	4.6963	4.4542	1.2788	0.86022	0.86837	0.55077	44	35	5
		JY	3.4889	3.1537	0.67448	0.63164	0.64917	0.29048	46	29	5
		A	4.4589	3.1859	0.69952	0.75183	0.66271	0.34976	61	28	4
		S	4.0006	3.6887	1.0073	0.69843	0.71349	0.43381	53	36	5
		O	2.7378	2.7070	0.95424	0.51799	0.58292	0.47712	39	26	4
Volume data	fertilized	J	1.3044	1.3020	0.99361	0.31280	0.32551	0.42792	18	16	5
		F	1.4777	1.3344	1.0951	0.34786	0.35047	0.47162	19	14	5
		M	2.3993	2.2023	1.3413	0.54624	0.53880	0.67067	21	17	4
		A	0.60681	0.60681	0.26892	0.14846	0.14846	0.11582	17	17	5
		M	3.8148	3.5367	1.7930	0.73788	0.72076	0.77219	36	30	5
		JY	0.48147	0.42704	0.11537	0.07804	0.07970	0.04968	72	41	5
		A	3.4698	3.2103	1.8813	0.56999	0.59921	0.81024	68	41	5
		S	3.5897	3.2526	1.6815	0.62670	0.64478	0.72420	53	33	5
		O	2.0924	1.9788	1.2415	0.34493	0.38895	0.53469	67	34	5
	unfertilized	J	1.2449	1.2220	1.0280	0.34727	0.35323	0.44272	12	11	5
		F	0.37448	0.37339	0.27519	0.09362	0.09807	0.11852	16	14	5
		M	0.96506	0.96376	0.59676	0.23143	0.23578	0.29838	18	17	4
		A	3.4705	3.3260	1.4439	0.70727	0.73527	0.72197	30	23	4
		M	4.4034	4.1607	1.4865	0.80656	0.81116	0.64019	44	35	5
		JY	2.4196	2.1488	0.51564	0.43805	0.44233	0.22207	46	29	5
		A	4.1127	2.5487	0.64397	0.69346	0.53016	0.32198	61	28	4
		S	3.7601	3.4672	1.5313	0.65645	0.67597	0.65951	53	36	4
		O	2.5478	2.4400	1.5632	0.48200	0.51910	0.78162	39	26	4

apply pooling to Class, Order and Family levels because in these fields extreme taxonomic schools of thought occur in algology. The aim of pooling was to find the answer to two questions: is it absolutely necessary to determine as far as species in the given pond, or it would have been enough to take only genera into consideration, and, in general, to what extent the differences in taxonomical conception have an effect on diversity (the questions will be given a fuller treatment in the discussion).
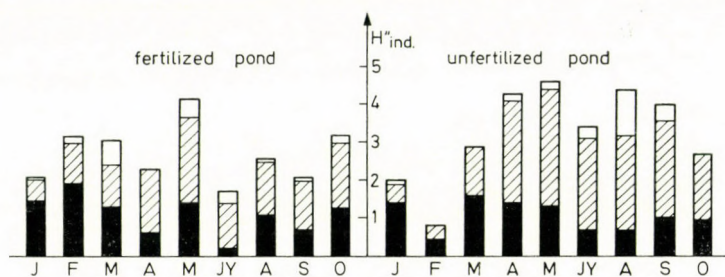
Fig. 2. Partition of the monthly diversity values, $H''_{(DGS)}$ computed from the individual data, into species $H''_{(DG)}$ S (empty part of column), genus $H''_{(D)}$ (G) (shaded part), and division $H''_{(D)}$ (black part). Left part of the Figure refers to the fertilized pond, right side to the non-fertilized, less eutrophic pond
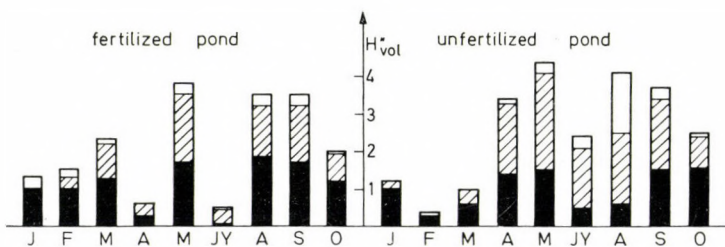
Fig. 3. Partition of diversity values, computed on the basis of volumen data, into species, genus and division components

The usual species diversity H'' (DGS) (Pielou 1966, 1969, 1975; Lloyd—Inger—King 1968, Symons 1972) has been partitioned into three taxonomic levels in the present case: $H''_{(D)}$ diversity of divisions per sample; $H''_{(D)}(G)$ averaged generic diversity within division, $H''_{(DG)}(S)$ averaged species diversity within genus (Figs 2 and 3):

$$H''_{(DGS)} = H''_{(D)} + H''_{(D)}(G) + H''_{(DG)}(S)$$

From the cumulative data of Table 6, $H''_{(DG)}(S)$ is obtained in such way that from the numbers occuring in the column designated as species, the numbers occurring in the column which is designated as genus are substracted. $H''_{(D)}(G)$ is obtained by substracting the value of division column from that of genus column. $H''_{(D)}$ is in agreement with the value of the division column.

In zoology, the determination of animals is done by means of separating by sorting several times (EGLOFF—BRAKEL 1973), therefore, the necessity of counting the hierarchical diversity occurs spontaneously; depending on whether the determination and selection has to be continued or there are enough differences already in the sample diversity at the taxonomic levels determined until them. The determination of the various algae does not take the same course, but irrespective of this our work would be greatly facilitated in practice if it would occasionally be enough to determine only up to genus levels.

The data of Table 6 are also shown in a histogram (Figs 2 and 3). As is clear from the figures, pooling causes a loss of information, but the trend essentially remains unchanged. The decrease of information increases on individuals/division level, and mainly in the non-fertilized pond. This is most detectable from the correlation coefficients of Table 7.

Table 7

Spearman's correlation coefficients of diversities and evennesses occurring on various levels of the hierarchy, and pooled in various ways

		Species-genus		Species-divisio	
		diversity	evenness	diversity	evenness
Ind.	fertilized	+0.9666***	+0.9500***	+0.7666*	+0.8833*
	unfert.	+0.9500***	+0.9333***	+0.2000 *N.S.*	+0.5000 *N.S.*
Vol.	fert.	+0.9500***	+0.9833***	+0.9550***	+0.9333***
	unfert.	+0.9500***	+0.9833***	+0.6166 *N.S.*	+0.6333 *N.S.*

4. The relationship between species-diversity within the various divisions and the total algal species-diversity

This examination was carried out by using only the individual data. Diversity within the division was computed as if only the individuals of a single division had been observed in the samples in each case. The diversity index calculated in this way was compared with that computed on the basis of the whole association. In the background of this examination the question appears that to what extent the species-diversity of a single taxonomical group (here division) can inform us on the species-diversity of the total phytoplankton.

In Table 8 we summarized the values according to divisions. It is remarkable that the diversity values of all the division are characteristically higher in the non-fertilized fishpond, with the exception of the *Euglenophyta* division, which is more diverse in the fertilized pond.

For the evaluation, SPEARMAN's correlation (Table 9), and for the species number BRAVAIS's correlation (Table 10), were applied. It is only the diversity

Table 8

Demonstration of the effect of cleaving of the data. Changes in the three indices computed from the individual per species data in each division and on the level of total algae

Divisio	Month	Fertilized pond			Unfertilized pond		
		s	H"	J	s	H"	J
Cyanophyta	J	5	0.79799	0.34368	2	0.50326	0.50326
	F	1	0.00000	—	2	1.00000	1.00000
	M	2	0.43275	0.43275	2	0.99108	0.99108
	A	1	0.00000	—	0	—	—
	M	1	0.00000	—	2	0.86313	0.86313
	JY	12	1.8774	0.52367	2	1.00000	1.00000
	A	9	1.4237	0.44911	2	1.00000	1.00000
	S	2	0.79186	0.79186	3	0.92551	0.58393
	O	4	1.3120	0.65598	6	2.2148	0.85680
Euglenophyta	J	2	0.27620	0.27620	1	0.0000	—
	F	5	1.1679	0.50297	5	1.8219	0.78466
	M	0	—	—	0	—	—
	A	2	0.81128	0.81128	2	0.09408	0.09408
	M	3	1.2389	0.78166	3	0.09563	0.06033
	JY	7	2.1539	0.76724	6	1.0186	0.39403
	A	12	2.7396	0.76418	6	1.0019	0.38759
	S	8	1.8358	0.61193	2	1.0000	1.00000
	O	3	0.78338	0.49426	3	0.59767	0.37709
Chrysophyta	J	1	0.00000	—	3	1.2389	0.78166
	F	4	1.6337	0.81687	1	0.0000	—
	M	7	1.0277	0.36607	11	1.9519	0.56423
	A	6	1.6133	0.62411	8	2.7504	0.91680
	M	9	2.7233	0.85910	11	2.9587	0.85525
	JY	5	1.4054	0.60526	7	1.2599	0.44877
	A	6	0.64120	0.24805	9	2.7831	0.87795
	S	8	1.0907	0.36356	9	1.4581	0.45998
	O	6	0.48605	0.18803	2	0.50637	0.50637
Pyrrophyta	J	2	0.12985	0.12985	1	0.00000	—
	F	1	0.00000	—	3	0.00899	0.56770
	M	1	0.00000	—	1	0.00000	—
	A	1	0.00000	—	2	0.91830	0.91830
	M	2	0.06101	0.06101	3	1.3788	0.86992
	JY	2	1.0000	1.0000	1	0.00000	—
	A	2	0.2164	0.2164	0	—	—
	S	2	0.99801	0.99801	2	0.32985	0.32985
	O	2	0.18362	0.18362	0	—	—
Chlorophyta	J	8	1.1264	0.37545	5	1.9953	0.85930
	F	8	2.3539	0.78463	5	0.81293	0.35011
	M	11	2.6045	0.75285	4	0.39787	0.19893
	A	7	2.7322	0.97322	18	3.6544	0.87637
	M	21	3.1821	0.72447	25	3.8709	0.83354
	JY	46	1.6813	0.30439	29	3.0979	0.63768
	A	39	1.6533	0.31091	44	4.0183	0.73602
	S	33	1.4842	0.29422	37	3.5127	0.67429
	O	50	3.1531	0.55867	28	2.0509	0.42662
Algae total	J	18	2.1613	0.51830	12	2.0294	0.56610
	F	19	3.2329	0.76105	16	0.7867	0.19667
	M	21	3.1174	0.70970	18	2.9472	0.70676
	A	17	2.2980	0.56220	30	4.3587	0.88828
	M	36	4.2057	0.81349	44	4.6963	0.86022
	JY	72	1.7994	0.29165	46	3.4889	0.63164
	A	68	2.6742	0.43929	61	4.4589	0.75183
	S	53	2.1272	0.37137	53	4.0006	0.69843
	O	67	3.2066	0.52861	39	2.7378	0.51799

Table 9

Spearman's correlation coefficients between indices computed per division and from the total algal community

	Fertilized		Unfertilized	
	H''	J	H''	J
Cyanophyta	−0.1429 *N.S.*	−0.1429 *N.S.*	−0.1905 *N.S.*	+0.0714 *N.S.*
Euglenophyta	−0.1905 *N.S.*	+0.0238 *N.S.*	−0.5714 *N.S.*	−0.6071 *N.S.*
Chrysophyta	+0.2619 *N.S.*	+0.3333 *N.S.*	+0.9048**	+0.7143*
Pyrrophyta	−0.8286 *N.S.*	−0.8286 *N.S.*	+1.000***	+0.8000 *N.S.*
Chlorophyta	+0.7000***	+0.6833*	+0.8833**	+0.5500 *N.S*

Table 10

Bravais's correlation coefficients of the total algal species number and of those per division

	Fertilized pond
Cyanophyta	+0.7035* ($m =$ 4.2340 $b =$ 23.8158)
Euglenophyta	+0.6837* ($m =$ 4.3452 $b =$ 20.9444)
Chrysophyta	+0.2646 *N.S.* ($m =$ 2.6964 $b =$ 25.6428)
Pyrrophyta	+0.7009* ($m =$ 33.333 $b = -$14.3333)
Chlorophyta	+0.9851*** ($m =$ 1.3414 $b =$ 7.9851)

	Unfertilized pond
Cyanophyta	+0.1939 *N.S.* ($m =$ 2.1333 $b =$ 30.4667)
Euglenophyta	+0.5239 *N.S.* ($m =$ 4.2440 $b =$ 22.2409)
Chrysophyta	+0.4460 *N.S.* ($m =$ 2.0236 $b =$ 21.7287)
Pyrrophyta	−0.2465 *N.S.* ($m = -$3.7935 $b =$ 40.9293)
Chlorophyta	+0.9858*** ($m =$ 1.1694 $b =$ 10.1079)

of the *Chlorophyta* division making the decisive portion of the flora correlates reliably with that of the total algae and this is indicated also in the species number.

Discussion

1. Do we need sample size dependent indices in the algological studies?

A characteristic part of the results obtained after running an artificial sample has been selected for Table 2. As can be seen, by increasing the average size of the data (n_i), H'' and H as well as J_1, J_2, J_3 and J_4 approximate each

other, while var H'' is decreasing. Special mention must be made of Samples 1 and 3, the structures of which are identical; but the number of individuals are ten times higher. It is here that the enormous disadvantage of BRILLOUIN's H emerges: it interprets Sample 3 as being more diverse. SHANNON's diversity at the same time does not change. CAIRNS and DICKSON (1971) published a programme to be promoted in practice. A similar but more expanded programme is used by us. The redundancy obtained by them deviates only slightly from our indices R_3 and R_4. The J_3 and J_4 values of Table 2 are $1 - R_3$ and $1 - R_4$. As can be seen, this redundancy is also sensitive to sample sizes, therefore, it can frequently be misleading instead, for practical purposes, equation

$$R = \frac{\log_2 S - H''}{\log_2 S}$$

is proposed. In the case of algological data, where the counting of total algal community is impossible, the algal flora of a pond can always be estimated only by means of samples. An index, which to such a considerable extent depends from the actual number of individuals, caused only trouble so it is not needed. The programme has been reduced considerably. In comparison with the earlier situation when 14 indices were used, now only S, H'' and J are printed together with their histogram. On request, the ASA FORTRAN programme is available (only in a limited number).

2. Is it ind./spec. or vol./spec. that provides a more satisfactory basis for computing the diversity?

The solution to this classical problem has acquired great importance also in algology. As can be seen in our subsection 2 when giving the results, diversities computed on the basis of two kinds of data — first of all in the fertilized fishpond — are different, i.e. they do not show the same trend. The question justifiably emerges, which one is more suitable for providing correct information? I believe, this is primarily determined by the aim of the investigation. Several authors (WILHM 1968, LLOYD—GHELARDI 1964) emphasize that the biomass data are more satisfactory because they equalize the size and biomass differences occuring among the individuals. In the case of plankton algae, this kind of difference is on the average 10—20 fold within one community. On the other hand, the data of the number of individuals provide greater significance to the individual. This is a definite advantage. It is commonly known (GOLTERMAN 1975) that smaller algae reproduce themselves at a quicker rate. Obviously, it is the individuals that are used as population dynamical basic units and not the data of biomass per species. A *Crucigenia* is destroyed not by the unit of biomass μm^3, or by the cell number, but in a way that the whole cenobium is, for example, pouched by an algivor, or it becomes deposited

out of the epilimnion, etc. The essence of the individual concept — in my view — is the common "fate" that is, the dynamics of the algal population can be traced more satisfactorily on the basis of the number of individuals. From the viewpoint of nutrition biology (for example, the diversity in the diet of planktonic crustacea), on the other hand, the diversity computed from biomass data according to algal species may be of importance. In this case, however, it is only the grazable size stock that is considered, because the large-bodied species constituting a great majority of the biomass are due to their large size safe from grazing. In estimating the algal volume we can undoubtedly make errors and these are even increasing by the fact that algae can change their water content, and so their volume as well, within broad limits, while their dry matter content remains unchanged. MARGALEF (1954) observed that the size and volume of algae decreased on heat contamination, while the dry matter content was unchanged.

The size of most of the algae is not proportional to their age; it grows to almost its maximum in the dark, at night, while during daytime it increase only insignificantly. In the case of *Ceratium hirundinella* (ENTZ 1933), growth takes 87.5% of its course, during 3 hours, which is 4.1% of algal life-span and again 91.6% of the volume increase takes place in 9 hours (12.5%). A cell of the same size can be young and "diluted" and by getting older it will be more concentrated at the same time. During daytime, the dry matter content falling to a unit of volume increases, the protein/carbohydrate ratio decreases. Identical volumetric biomasses do not necessarily mean identical nutritive values.

We know from the investigations of STEENBERGEN (1975) that within the *Scenedesmus* cell, 2—4 autospores come into existence already in the first half of the day, and again 8 of them in the second half of day; these are biochemically already new individuals, but they are considered as new counting units, individuals, only after getting out the cell.

The number of individuals and the biomass values give an estimation of the "importance" of the species in the community. We have knowledge of the fact that certain species can be more important for a community then would be indicated by their number or volume. The effect exerted by species on the limiting nutritive element accentuates the importance of the species. When computing the algal diversity, it is first of all the nutritive strategist species having an effect on the level of limiting nutritive element that should be stressed. Whether this weight should be increasing or decreasing in nature, and what scale it should indeed cover — these are questions which should be decided by means of investigations to this end, and on the basis whether the introduction of e.g. an algal species which produces phosphatase would increase, or decrease, the diversity of the community. Our present algaecological knowledge has not yet reached a satisfactory stage where our analyses could be expected to deal with such distinguished considerations.

Concerning diversity changes, in the majority of cases we attempt to give an explanation by means of changes in the abiotic environment, primarily because we have little knowledge of the biotic effects. On the other hand, diversity changes which do not correlate with the changes in the abiotic environment can evidently be attributed to the biotic environment, to the interaction of the community members. This interaction may be both positive and negative. The positive effect is interpreted in the following way: a new species arises, which would not considerably increase diversity yet, but it has an effect that it makes a new niche open, provides the possibility for the settlement of new species (S increases), with a possibility of stimulating the reproduction of species which had smaller number of individuals until then (HUNTSMAN—BARBER 1975), thus J can grow. Species opening new niches are for example the ones which produce phosphatase in a phosphor-limited environment, opening thus new P-resources, and raising the P-level periodically (SOEDER et al. 1971), and again producing chelate in a ferro-limited environment (MURPHY et al. 1975). The motivation of algae in producing chelate is not based on altruism but mainly on selfishness, nevertheless the residue may still be enough for other species.

The negative effect may come from inhibition (see the literature quoted by HUTCHINSON 1967, FOGG 1975), which may manifest itself in a decrease in evenness, with the possibility of elimination of species. The apparently incomprehensible decrease in diversity (which is not explainable by abiotic causes, e.g. contamination, light decrease etc.) can ensue also in the cases when the examined population gets under the effect of such selective grazing as is not prevalent in the reference community, or under the effect of invasion by a species-specific parasite.

As a final conclusion it can be inferred that in the case of algae it is most advisable to compute the diversity index on the basis of both the number of individuals and the volume.

3. Hierarchic diversity

If the data were pooled for genera, then the information loss is surprisingly small. This is because there are many genera (for 2.3 species falls one genus). If the species were more cogeneric, the information decrease would have been greater. The pooling was concerned with 36 genera having 165 species, while the other 65 genera were monospecific. The genera possessing more than 5 species were as follows: *Scenedesmus* (37), *Tetraëdron* (12), *Phacus* (10), *Euglena* (10), *Trachelomonas* (9), *Ankistrodesmus* (8), *Chlamydomonas* (5). It is rare that the species of a genus can be found together in one sample; this seems to be the main cause of the minor information loss. If, for example, the *Scenedesmus acutus* and the *Scenedesmus quadricauda* were in separate

samples, then in the diversity index there is no indication of the fact that they were only mentioned as *Scenedesmus* sp. in our quantitative list. Even if the species of a genus live together, then the number of their individuals is often so small that they do not significantly influence the diversity index, which is mainly sensitive to the most frequently occuring 10—15 species (SAGER—HASLER 1969, BRADBURY 1973). Here it should also be mentioned that in our article we have used the term species diversity throughout, whereas essentially the term infraspecific would be the correct one since the subspecific taxa have not been included in the species, but they appear as separate sources of information. Nevertheless, the result has even less been influenced by this than by pooling to genera, because the number of infraspecific taxa was smaller.

A practical conclusion is that in the algal diversity examinations, in these fishponds, it would not have by all means been necessary to determine to the species; by determining only to genera in all probability — we could have obtained the same results. An unjustifiable merging of certain genera (for example, *Scenedesmus* genus in the conception of PHILIPOSE 1963) does not essentially influence the conclusions that can be drawn on the basis of diversity. Naturally, there can be such communities in relation to which this statement is not valid; if there occur in the sample only a few genera with many species, then the pooling can cause a considerable decrease in information (PIELOU 1969, SYMONS 1972, PIELOU 1975, LLOYD—INGER—KING 1968).

Pooling by division — primarily in the non-fertilized pond — brings about a considerable loss of information. This could only be expected since the number of divisions (s) is small, and their distribution is uneven. This part of the examination mainly serves only as a basis for comparison with pooling up to genera.

MCINTIRE and OVERTON (1971) carried out similar examinations in algae, but there is no special reason for a comparison of our results with theirs because of the fact that they used different taxocens (attached diatoms), and other kinds of biotop (estuary). It would be superfluous to evaluate in detail the components of the hierarchic diversity in the two fishponds; evaluation is possible by a simple look at Figs 2 and 3. Anyhow, $H''_{(DG)}(S)$ is surprisingly small, and again $H''_{(D)}(G)$ is surprisingly great. These two values are characteristically higher in the non-fertilized pond.

4. *Relationship between the species diversities in individual divisions and those in the total algal community*

As has become clear from our results, it is only exceptional that the species diversity within one division is in agreement with that computed on the basis of the total algal flora. Such approximate agreement can occur only in

a division that is dominant in the community, and represents a significant ratio of species number and the number of individuals in the species. However, such is practically the case already when 10—20 of the species with the greatest $\left(\text{or rather about } n_i \approx \frac{N}{e}\right)$ number of individuals belong to the division at issue. The two values are in complete agreement if the community consists of the members of only one division. In the case examined, the *Chlorophyta* division was dominant over all the other divisions, and its species diversity was positively correlated in both ponds with the total algal species diversity. The species diversity of the other four divisions did not behave identically in the fertilized and the non-fertilized ponds, and, their correlation with the diversity of the total algal community was not significant.

From the investigations the conclusion can be drawn that in the plankton of the two eutrophic ponds, the *Chlorophyta* determine decisively the diversity. We should not be too erroneous if we wanted to characterize the water by means of the diversity of green algae. On the basis of this, presumably, the algal species diversity of rivers can also be satisfactorily estimated by means of the values of the taxocen of the epibiotic diatoms, since this constitutes a characteristic part of the biocoenosis of the river. Similar extrapolation is used in almost all the diversity examinations. In characterizing a pond, we do not survey the whole flora, but only, for example, the phytoplankton, and this is not always satisfactory, sometimes, however, we may be forced to do this. When, for example, we want to estimate the difference between the diversities of two taxonomic groups that are not significant quantitatively, then the diversity indices will have to be computed for them separately, not by extrapolation.

The diversity of the *Euglenophyta* algae was greater in the fertilized lake. This fact is in agreement with the picture drawn of them. We must note, however that the saprobity index of PANTLE-BUCK was not different between the two ponds (HAJDU 1974).

The next article in this series will deal with the resemblance between diversities of the algae of the fishponds.

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TERATOLOGICAL GOLGI APPARATUS IN THE MESOPHYLL CELL OF THE FOLIAGE-LEAF OF SINAPIS ALBA

By

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In the section prepared from the mesophyll cell of the foliage-leaf of white mustard (*Sinapis alba* L.) an electronmicroscopic structure different from the known cell organells was observed. The plants were 5 weeks old, the preparatum was made from the 6th foliage leaf. For the fixation glutaraldehyde-OsO_4 was used. The well-definable structure, consisting of tybuls and vesycules, excludes the artifact. On the basis of its pattern, size and closed built-up, and owing to the lack of rhizozomes, it is assumable that the structure is a deformed, teratological form of a Golgi apparatus.

The biological application of the electronmicroscope has lended an enormous impetus to cytological researches. The capability to break-down to a large extent the various objects examined has created the possibility for us to obtain knowledge of several structures which we had not been able to examine earlier.

The introduction of the electronmicroscopic techniques has made also possible the deep-going examination into the characteristics and functional peculiarities of the Golgi apparatus. As it is known, the Golgi apparatus can be found in organisms from the lower order to those of the higher orders, in both the plant cells and the animal cells as well. It is in general characteristic of the Golgi apparatus that it consists of the closely adhering cisterns and of the smaller or greater vesicules lying around them (Photo 1). Many kinds of differences have, however, been pointed out in relation to the Golgi apparatus, especially in the quality, quantity and grouping of the cisterns (Photo 2, 3, 4 and 5).

The basis of the great variety in morphology and structure is the difference in development, differentiation and function. Namely, the Golgi apparatus plays an important part in the production of increments, in the synthesis of the carbon hydrate components of plant cell-walls, and proteids, etc. The picture obtained by the electronmicroscopic technique is to a large extent influenced by the method used for the demonstration (fixation), and also by the plane of cutting.

The relationship of the Golgi apparatus with other components of the cell has since long been supposed. For example, in the growing cell, the close relationship of the Golgi apparatus with the seed membrane is observable.
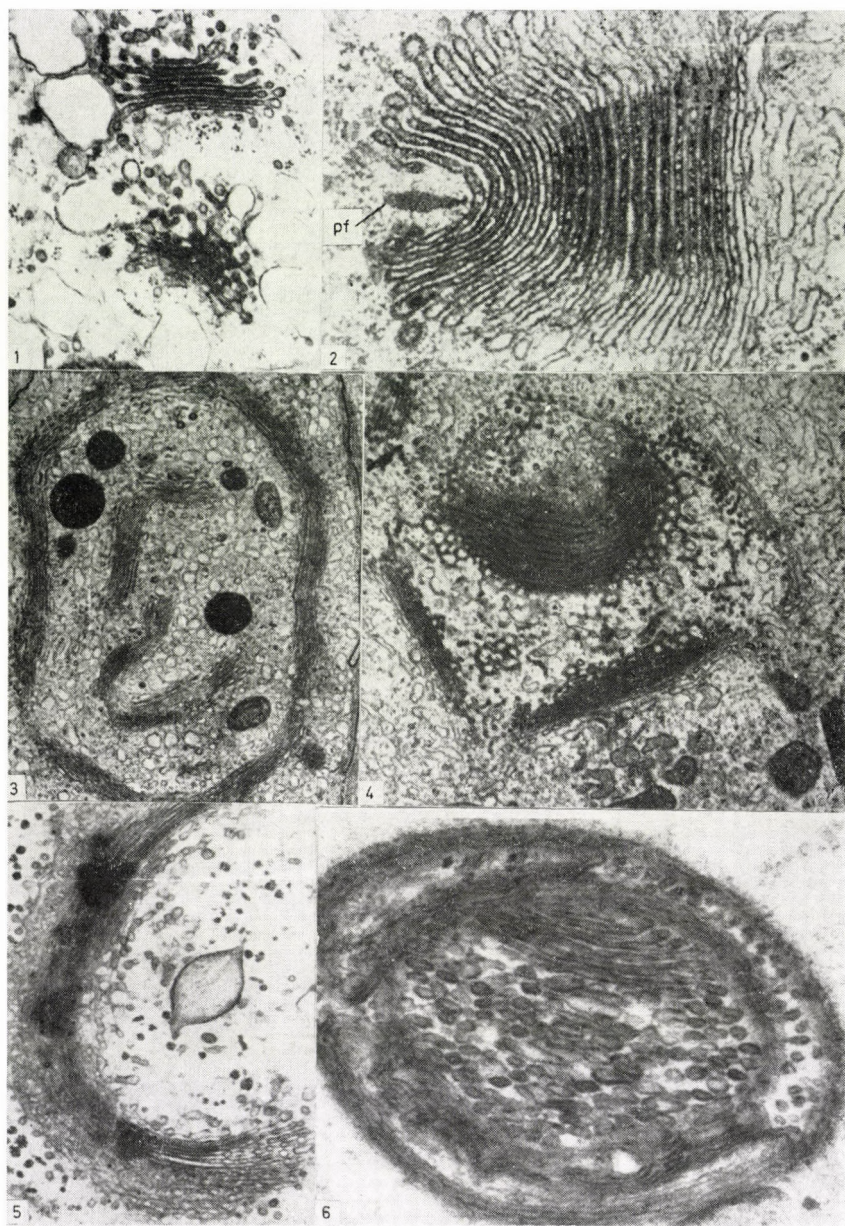
Photo 1. Typical GOLGI apparatus in *Nitella* cell; magn. 28,000 × (TURNER 1965). *Photo 2.* GOLGI apparatus of *Trichomonas termopsidis;* magn. 69,000 × (AROS-GRIMSTONE, 1968). *Photo 3.* Grouping of GOLGI apparatuses in the epididymis cell of the tame rabbits; magn. 9,000 × (FAWCETT, 1966). *Photo 4.* Various section of GOLGI apparatuses from the spermatyde of the *Helix aspersa;* magn. 7,600 × (DAUWALDER et al. 1972). *Photo 5.* Longitudinal section of GOLGI apparatuses in the *Trichomonas termopsidis;* magn. 25,000 × (AMOS-GRIMSTONE 1968). *Photo 6.* The structure observed by us from the mesophyll cell of the foliage leaf of *Sinapis alba;* magn. 30,000 ×

Its function is also in connection with the lysosomes and the endiplasmatic reticulum. With respect to the latter, NOVIKOFF (1971) detected some proofs.

The material of knowledge that has so far been accumulated in relation to the GOLGI apparatus is of a large scale, nevertheless, as far as its function and construction are concerned, there are aspects, which have not been revealed up to the present time.

In our paper we present a structure which has been prepared from the mesophyll of the foliage leaf of white mustard (*Sinapis alba* L.) by means of glutaraldehyde-OsO_4 fixation, in the course of an electronmicroscopic examination (Photo 6; the sixth foliage leaf of a 5-week-old plant).

The white mustard was grown in phytotron, in sand culture, with the application of KNOP nutrient solution. In a daily rhythm, the temperature has changed between 18—25 °C, and again the relative vapour content of the air between 45 and 70%. The photoelectric intensity was 12.000 Lux (with Hungarian make F_{29} photoelectric tubes); the time of photoelectricity was daily 16 hours.

The structure lied in the cytoplasm along with the chloroplasts of the cell. Its size: 1—2 μ. Its well-definable construction, consisting of tubules and vesyculums, excludes the preparation artifact. Owing to its pattern, size and close built-up as well as the lack of rhibosomas, it is assumable that the structure observed is a deformed teratological variety of the GOLGI apparatus. We do not consider indicated to describe the new cytoplasm as an organell.

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XENOBIOTICS AND SOIL MICROBIOTA AFFECTED BY XENOBIOTIC INTERACTIONS VI. LUPIN-RHIZOBIUM SYMBIOSIS AND HERBICIDE COMBINATIONS*

By

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The effect of 108 herbicides and combinations was observed on the root nodulation of *Lupinus albus* in culture ecosystems rich in native rhizobia. Generally the macrosymbiont proved to be more sensitive to the herbicides than the microsymbiont. The inhibition of *Lupinus albus—Rhizobium lupini* symbiosis by herbicides and herbicide combinations is manifest by the reduced size and number of root nodules formed on the tap root. The Karmex-Afalon-Satecid combinations gave quite good results for the chemical weed control of *Lupinus albus* cultures.

The effect of herbicides and herbicide combinations on the root nodulation and the biological production of plants was studied for seven and four years respectively in lupin culture-consociations (*Lupinus albus*, *L. luteus*) in Nyírség the main lupin growing area of Hungary, in slightly acidic brown forest soil rich in native rhizobia.

Some of the results concerning mainly *L. albus* will be presented here with special regard to the root nodulation. In the course of our comparative investigations carried out in these culture ecosystems it was established that of the symbionts the macrosymbiont is more sensitive to the herbicides than the microsymbiont: the same herbicide preparation (3-cyclohexyl-5,6-trimethylene uracil) was lethal to the *L. albus* yet it was not lethal to L. *luteus*, both of them belonging to the same genus. The *Rhizobium lupini* strains able to "infect" all of the *Lupinus* species, after *L. albus* is destroyed formed effective symbiosis with *L. luteus* in the same soil.

On applying N-(3,4-dichlorophenyl)-N',N' dimethylurea after the destruction of *L. luteus* the undisturbed symbiosis of *L. albus* and *R. lupini* could be observed.

The *Lupinus albus* was killed by about 4% (2,4,5-T, atrazine, ametryne + atrazine, lenacil) of the studied 108 herbicides (their trade, common and

* As a lecture presented at the International Symposium on "The interaction of soil microflora and environmental pollution" Pulawy, Poland, 7—10 Sept., 1977.
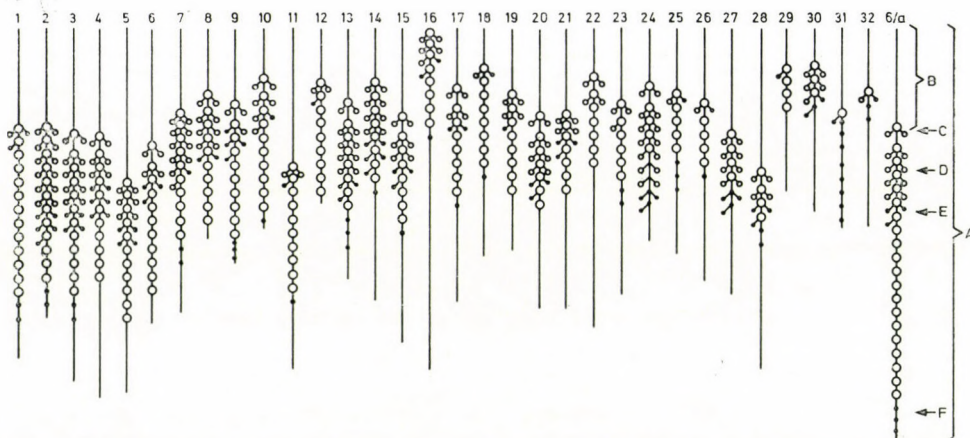
Fig. 1. Effect of different herbicide treatments on the root nodulation of *Lupinus albus* (field exp. 1973). 1 = DCPA; 2 = Gesapax; 3 = Gesaran; 4 = Patoran; 5 = Afalon; 6 = Treflan; 7 = Control, unhoed c.; 8 = Tenoran; 9 = Avadex; 10 = Venzar; 11 = Sys 67; 12 = Dachtal; 13 = Legurame; 14 = Maloran; 15 = Satecid 50; 16 = Banlene "plus"; 17 = Vegadex; 18 = DCU Diralid; 19 = Planavin 75; 20 = Igran 50; 21 = Aniten D; 22 = Amchem; 23 = Trimetrin; 24 = hoed control; 25 = NaTa; 26 = Endothal; 27 = Ramrod; 28 = Aniten M; 29 = Cotoran; 30 = Cartex M; 31 = Gesaprin 50; 32 = Gesatop 50; 6/a = Venzar (extreme example not affected by herbicides). A = the whole length of root; B = distance between the crown and the first nodule; C = "large" nodule on the tap root; D = medium size nodule on the lateral root; E = small nodule on the lateral root; F = small nodule on the tap root
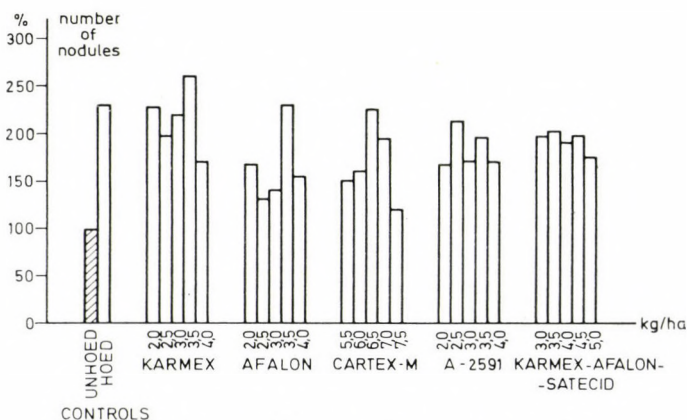
Fig. 2. Root nodulation of *Lupinus albus* (1973)

chemical names are found: BORBÉLY et al. 1976). But not the *L. luteus*, the *Lupinus luteus* was destroyed by 10% of the preparations (MCPA, mecoprop, monuron, diuron, dicamba + 2,4-D, chlorthiamide, secbumetin, terbutryne, chloral, monolinuron + chloral) but they were not significantly harmful to the *L. albus* and with the surviving cells of *R. lupini*, an effective symbiosis was formed.
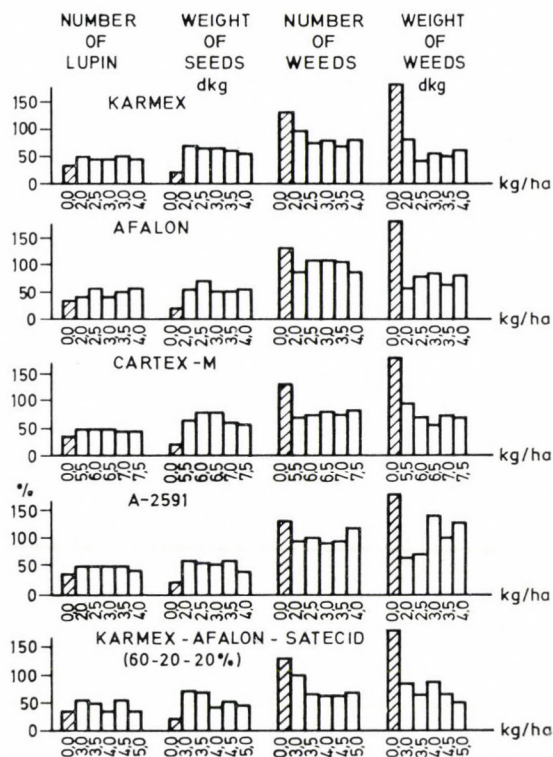
Fig. 3. Effect of herbicides on *Lupinus albus* (1973)

Generally those characteristic delayed root nodulation forms on the roots of *Lupinus* species developed in the soil treated with herbicide combinations (indicating the reduced biological production of the symbiosis) which are formed on the roots of legumes on the effect of fungicides (Seed dressings of vetch: KECSKÉS and VINCENT 1969) were not found.

The inhibition of the lupin-rhizobium symbiosis by herbicides and herbicide combinations is manifested by the reduced size and number of the root nodules formed on the tap root (Fig. 1).

As regards the number of nodules in the herbicide combination treatments (Fig. 2) in some cases more were found than in the unhoed control plots (average 20 plants of each plot) but statistically evaluable differences were not proved.

With respect to our own combination (Karmex-Afalon-Satecid: diuron linuron-propachlor) gave quite good results in the root nodulation, the number of plants, the yield of seeds and the weeds were restricted by these treatments (Figs 3 and 4).
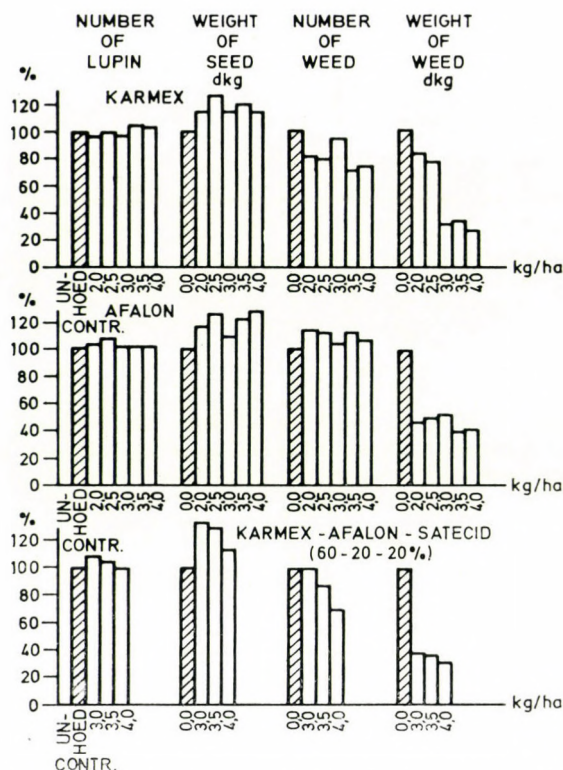
Fig. 4. Effect of herbicides on *Lupinus albus* (1973, 1974, 1975, 1976)

These results supported our earlier findings (Borbély et al. 1976) that not only the number but the weight of weeds is necessary for establishing the efficiency of herbicides or the herbicide combinations.

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RELATIONSHIPS BETWEEN GROWTH CHARACTERISTICS OF MAIZE HYBRIDS AND SUGAR BEET VARIETIES

By

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On the basis of a correlation matrix between the growth characteristics (RGR, NAR, LAR, RLGR, LAI, CGR and efficiency) of two genetically different maize hybrids (DKXL-342 and OSSK-218) and two sugar beet varieties (Beta poly M/102 and Kawemono), principal component analyses were made to show whether a factor can be detected in relation to which the growth analysis characteristics of the two different agricultural plants, grown among different conditions, react similarly, or whether there exists a factor characteristic only of one species. The first component of the maize hybrids contains a factor which can be considered identical in the hybrids. This can be regarded as the general factor. The second component separates the hybrids, and this may be the genetical factor. Since the factor occuring in the first component does not separate the genetically different hybrids and seems different also from that occuring in the sugar beet varieties, this factor may be characteristic of maize. Similarly, in the case of sugar beet varieties, the first component may contain a factor characteristic of sugar beet. No separating factor occurs in the sugar beet varieties. The signs RGR and RLGR, RGR and efficiency, NAR and efficiency weights are identical in the various components in both species (with the exception of one case in the maize hybrids). The factor influencing RGR acts similarly on RLGR and efficiency, and the one which effects NAR acts similarly on efficiency as well. LAR and LAI reacts in plants contrarily to all factors, they can never be found on identical parts of the axes. All this, indicates similarities between the different species. It seems, that although we analysed very different species, also grown among different conditions of cultivation, there exist factors to which the various growth analysis characteristics react similarly. In assessing the results, we must take into consideration that they are valid only in the system chosen.

The relationships between the characteristics used in growth analysis and the climatic factors, nutrient supply and density, have been studied by several researchers (e.g. Briggs—Kidd—West, Blackman, Watson, Thorne, Hughes, etc.). Investigations were made in experimental conditions in numerous cases, thus the effect of the treatment(s) was guaranteed. The treatment was selected on the basis of previous knowledge and hypothesis. The effect of temperature, radiation and stand density on the characteristics was not frequently examined. The relationships between the characteristics have only been studied to a slight extent. The cause of this may be found in the fact that correlations exist among the characteristics (Briggs—Kidd—West 1920, Watson 1952).

Starting from the correlations extent between the growth analysis characteristics of two agricultural species (maize and sugar beet), we attempted

to detect whether there exists a factor to which the growth analysis characteristics of two different species grown among different conditions react similarly, and whether there can be found a factor characteristic only of the species.

Material and method

The description and growth analysis of two genetically different maize hybrids (DKXL-342 and OSSK-218) were published by PRÉCSÉNYI—CZIMBER—CSALA—SZŐCS—MOLNÁR and MELKÓ (1976), on the basis of plants cultivated at Bábolna, in 1974.

The description and growth analysis of the two sugar beet varieties (Beta poly M/102 and Kawemono) were given by PRÉCSÉNYI—BOGNÁR—CZIMBER and VIRÁGH (1977). The varieties may genetically be closely related (no data on the producing of Kawemono were provided by the producer firm): morphologically and in growth characteristics the varieties are very near to each other. The growth analysis was made on the basis of plants grown at Csorna, in 1976.

In both cases, the data were obtained from plants grown in the fields.

Table 1

Correlation between the growth characteristics of maize hybrids (OSSK-218 and DKXL-342)

OSSK \ DKXL	RGR	NAR	LAR	RLGR	LAI	Efficiency	CGR
RGR		0.600	0.491	0.845	—0.545	0.709	—0.409
NAR	0.173		—0.700	0.200	0.164	0.654	0.173
LAR	0.591	—0.573		0.782	—0.973	0.273	—0.900
RLGR	0.754	—0.436	0.927		—0.854	0.482	—0.773
LAI	—0.536	0.554	—0.963	—0.873		—0.273	0.927
Efficiency	0.554	0.718	—0.154	0.055	0.163		0.000
CGR	—0.464	0.645	—0.900	—0.809	0.936	0.254	

Table 2

Correlation between the growth characteristics of sugar beet varieties (Beta poly M/102 and Kawemono)

Kawemono \ Beta poly	RGR	NAR	LAR	RLGR	LAI	Efficiency	CGR
RGR		0.796	0.846	0.843	—0.804	0.752	0.028
NAR	0.912		0.500	0.753	—0.489	0.884	0.378
LAR	0.703	0.375		0.653	—0.718	0.389	—0.207
RLGR	0.861	0.798	0.568		—0.639	0.794	0.139
LAI	—0.682	—0.453	—0.800	—0.564		—0.552	0.389
Efficiency	0.912	0.939	0.455	0.819	—0.550		0.252
CGR	0.253	0.478	—0.253	0.271	0.343	0.371	

By means of principal component analyses of the matrices of correlations between the characteristics components can be produced that are uncorrelated and in which the certain variates (in the present case the growth analysis characteristics) have weight. Analyses of the weight matrix may call attention to phenomena which have not or hardly been studied so far; they may point to further researches (Lawley—Maxwell 1963). The identification of the components with a certain (e.g. an ecological) factor frequently encounters difficulties, because the factors must be independent owing to the independence of the very components.

RGR, NAR, LAR, RLGR, LAI, CGR and efficiency were drawn into our analyses. For the basic data of principal component analyses, we used a correlation matrix. The correlations between the various characteristics were calculated by the Spearman rank correlation coefficient (See Table 1 and 2). Evaluation was made on the basis of weights obtained after rotation. Components were considered in which the weight of at least one of the variables was greater than 0.5.

Results

Examining the weights of the maize hybrids (Table 3) it appears that the hybrids do not separate in the first component. There is a factor in this component which in comparison with LAI and CGR acts oppositely on the LAR and RLGR of both hybrids. If it has a positive effect on LAR and RLGR,

Table 3

Matrix of component weights. Maize hybrids

Component / Variable	DKXL				OSSK			
	I	II	III	IV	I	II	III	IV
RGR	0.394	—0.262	0.480	0.748	0.518	0.505	0.683	—0.086
NAR	—0.145	—0.936	0.384	0.247	—0.446	0.631	0.054	—0.624
LAR	0.798	0.642	0.222	0.249	0.936	—0.103	0.255	0.156
RLGR	0.754	—0.055	0.283	0.550	0.830	0.075	0.455	0.205
LAI	—0.941	—0.175	—0.194	—0.179	—0.980	0.094	—0.121	—0.089
Efficiency	0.092	—0.206	0.955	0.240	—0.081	0.938	0.135	—0.083
CGR	—0.986	—0.074	0.091	—0.132	—0.907	0.180	—0.131	—0.188
Variance, %	60.2	32.8	7.8	2.9	63.5	29.2	2.7	2.4

then it is negative on LAI and CGR. This component can be called LAR-RLGR versus LAI-CGR component. Since the hybrids react similarly to the content of this component, it can also be called general component. The second component may have a genetical content, since it separates the hybrids. In DKXL, the third is the efficiency component. The fourth component of DKXL, and the third component of OSSK is the component RGR. The fourth component of OSSK is NAR.

In DKXL there are two, in OSSK there is one, component in which a variable each stands with an opposite sign.

If the sequence of components is considered an order of importance, it becomes evident that, although there are components in hybrids containing

factors which effect efficiency and RGR, their place is different in the row of components.

The signs of the weights of RGR and RLGR, of NAR and efficiency, of RGR and efficiency, of LAI and CGR, are with the exception of one component, identical in hybrids. The weight signs of LAR and LAI are opposite is the case of all components in the hybrids.

Each of the factors has a unidirectional influence on the LAR of DKXL. Similarly, each of the factors has a unidirectional influence on LAI, but it is of an opposite direction as the one effected on LAR. In the case of OSSK, the factors effect RLGR identically.

From the matrix of the weights of the components of sugar beet varieties it appears (Table 4) that the varieties do not separate according to any of the components. Contrarily to the variable with a great weight on the individual components, there are variables with a small weight in most of the cases;

Table 4

Matrix of component weights. Sugar beet varieties

Variable \ Component	Beta poly				
	I	II	III	IV	V
RGR	0.558	0.020	0.688	0.235	0.345
NAR	0.851	0.263	0.346	0.118	0.128
LAR	0.195	−0.141	0.938	0.136	0.180
RLGR	0.558	0.075	0.436	0.673	0.200
LAI	−0.354	0.342	−0.472	−0.176	−0.709
Efficiency	0.915	0.109	0.160	0.245	0.207
CGR	0.197	0.966	−0.098	0.036	−0.124
Variance, %	64.2	22.2	6.7	3.1	2.3

Variable \ Component	Kawemono				
	I	II	III	IV	V
RGR	0.806	0.500	0.117	0.221	0.153
NAR	0.920	0.156	0.261	0.169	0.116
LAR	0.252	0.926	−0.173	0.155	0.157
RLGR	0.637	0.328	0.123	0.674	0.125
LAI	−0.379	−0.569	0.317	−0.139	−0.642
Efficiency	0.909	0.213	0.164	0.188	0.170
CGR	0.284	−0.168	0.935	0.064	−0.105
Variance, %	64.9	24.3	4.6	3.1	2.0

exceptions are the second component of Kawemono and the third component of Beta poly, although in this latter one the weight does not reach the 0.5 value.

On the first component, NAR and efficiency have great weights. With the exception of LAI, the other variables have a positive weight, the weight of LAI does not even reach 0.4. The first component may contain a factor which may be a general factor, characteristic of the two varieties. On the second component of Beta poly and on the third component of Kawemono, the pattern of the weight signs is identical. The weight of the CGR is maximum on the two components. The third component of Beta poly seems identical with the second component of Kawemono, LAR is opposed to LAI. The fourth and the fifth components can be regarded as identical in the varieties, the weights of the variables differ only to a slight extent from each other. On the fourth component it is RLGR, on the fifth LAI, which has the greatest weight.

In both varieties there is one component which reacts oppositely on two variables. In the sequence of the components of the varieties, opposite signs occur in the first three, while the content of the fourth and fifth components may be identical.

The signs of RGR, NAR, RLGR, and of the efficiency weight are identical on all components. The signs belonging to the LAR and LAI weights are in opposition on the components.

Let any one of the two varieties be considered, the signs of the weights of RGR and RLGR, of RGR and efficiency, of NAR and efficiency, are identical on the components, with the exception of one case of the maize. This means that the factor effecting RGR has a similar directional influence on RLGR and efficiency; and again, the factor effecting NAR has an identical directional effect on efficiency. Naturally, this holds also for the other two variables: the factor effecting efficiency effects in the same direction, for example, NAR.

The opposition between LAR and LAI exists both in the maize hybrids and the sugar beet varieties. This opposition is so strong that if it is demonstrated on the components, they will get in different quarters of a co-ordinate system. Similarly as the weights on the axes, then the two characteristics lie in opposite quarters in a two-dimensional case; if, for example, LAR is in the first quarter, then LAI is in the third. This phenomenon is worthy of attention because there are two different species involved.

When assessing the results, we must naturally also take into consideration the fact that they are valid only in the chosen system (for the seven growth analysis characteristics mentioned above).

Although we endeavoured to identify the components as far as possible this does not mean that they are the very factors. On the basis of the results of the analysis, the direction of further research may be indicated and the questions posed be solved by means of further research.

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NICHE STUDIES ON SOME PLANT SPECIES OF A GRASSLAND COMMUNITY III

OVERLAP INVESTIGATIONS BY CLUSTER ANALYSIS

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The authors studied the niche overlap of nine plant species of a grassland community, in two dimensions (soil moisture content and root depth, and the combination of these), in summer and autumn. For a further analysis of the overlaps, cluster analysis is suggested in this paper, while for the estimation of overlaps, the use of the Euclidean distance between species (chord distance, d), or more exactly the formula $(2-d^2)$ (Orlóci 1967). Cluster analysis was carried out on the basis of the average linkage clustering. The summer and the autumn dendrograms can be compared with one another; seasonally, the similarity is greater according to the soil moisture content, and again it is smaller according to root depth; factor combinations take a middle position. The dendrograms also testify the authors' earlier statement according to which the overlap picture according to factor combinations is nearer to that according to root depth.

Niche overlap between two or more species is an indication of common resource exploitation. It implies a certain degree of similarity in the requirements of the various species (Shugart—Patten 1972). The lack of overlap is an indication of efficient resource division (Cody 1968).

A way of estimating the degree of overlap is to determine the Euclidean distance (d) between species on the niche axis examined, or the so-called chord distance (Orlóci 1967). The value of chord distance may vary between 0 and 1.41. The greater this value is on the axis examined, the smaller the overlap between the two species given. For the estimation of the overlap value, the application of value $(2-d^2)$ is suggested.

By using the cluster analysis we wanted to obtain an answer whether, on the basis of the overlap values, there can be found clusters among the species. In the analysis, first those species fuse among which the overlap is great, the resource exploitation is similar, and the requirements are near to one another. Then the fusion similarity decreases in the course of fusion as more and more species belong to the various groups.

Material and method

In our former two papers (Fekete et al. 1977; Précsényi et al. 1977) the methods, aims and results of the niche examinations into plant species of grassland communities were described. To the present paper the data from the preceding studies have been used (Tables 1—3).

Table 1

Niche overlap of species. Soil moisture

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca		1.56	1.84	1.22	1.00	1.96	1.76	1.72	1.76
Medicago	1.57		1.72	0.81	0.76	1.42	1.74	1.62	1.48
Thymus	1.80	1.99		0.86	0.82	1.83	1.86	1.53	1.17
Fumana	0.84	0.81	0.85		1.91	0.49	0.50	0.21	0.69
Euphorbia	1.14	1.23	1.24	1.82		0.54	0.56	0.47	0.96
Carex	1.49	1.71	1.71	1.49	1.85		1.77	1.86	1.34
Cynodon	0.91	0.92	0.94	1.97	1.93	1.62		1.42	1.54
Equisetum	1.20	0.93	0.93	1.94	1.83	1.55	1.93		0.82
Centaurea	1.19	1.10	1.05	1.68	1.89	1.66	1.92	1.75	

In the upper semimatrix the summer values, in the lover semimatrix the autumn values.

Table 2

Niche overlap of species. Root depth

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca		1.25	1.68	0.05	1.05	1.09	1.87	1.78	1.40
Medicago	1.64		1.89	0.00	0.45	1.98	1.07	1.18	0.53
Thymus	1.69	1.99		0.00	0.67	1.82	1.51	1.61	0.85
Fumana	0.37	0.17	0.12		1.42	0.00	0.62	0.00	0.00
Euphorbia	1.23	0.48	0.36	1.24		0.32	1.24	0.64	1.07
Carex	1.96	1.93	1.89	0.24	0.90		0.92	1.13	0.27
Cynodon	0.49	0.36	0.24	1.18	1.27	0.42		1.68	1.33
Equisetum	1.13	0.78	0.75	1.66	1.73	0.96	1.39		0.63
Centaurea	0.96	0.84	0.74	1.28	1.46	0.89	1.76	1.78	

In the upper semimatrix the summer values, in the lover semimatrix the autumn values.

The so-called average linkage clustering method has been used (SOKAL-MICHENER 1958).

The maximum fusion similarity: 2; the minimum one: 0. The distance between 0 and 2 was arbitrarily divided into four parts: 2.0—1.5; 1.5—1.0; 1.0—0.5; 0.5—0. In this way, a more easily surveyable picture of fusion was obtained.

For comparing the structures of the dendrograms, PHIPPS's method (1971) was used with the difference that the chord distance was calculated.

Table 3

Niche overlap of species. Combination of soil moisture and root depth

	Festuca	*Medicago*	*Thymus*	*Fumana*	*Euphorbia*	*Carex*	*Cynodon*	*Equisetum*	*Centaurea*
Festuca		0.53	1.09	0.05	0.53	1.01	1.27	1.47	0.89
Medicago	1.31		1.70	0.00	0.18	1.26	0.52	0.56	0.20
Thymus	1.45	1.86		0.00	0.24	1.30	0.89	0.96	0.54
Fumana	0.38	0.13	0.20		1.49	0.00	0.14	0.00	0.00
Euphorbia	0.86	0.34	0.29	1.08		0.35	0.00	0.21	0.59
Carex	0.97	1.21	1.30	0.28	0.67		0.69	1.12	0.26
Cynodon	0.49	0.14	0.28	1.18	1.17	0.40		1.54	0.43
Equisetum	0.50	0.38	0.16	1.05	1.16	0.33	0.97		0.00
Centaurea	0.78	0.27	0.28	0.78	1.39	0.27	1.50	1.11	

In the upper semimatrix the summer values, in the lover semimatrix the autumn values.

Results

Soil moisture content

As regards soil moisture content, different clusters took form in summer and in autumn (Figs 1 and 2). In summer, four clusters of two species can be found between 2.0 and 1.5 similarity values. One species, *Centaurea*, fuses with the *Festuca-Carex-Thymus-Cynodon* cluster with similarity values between 1.5 and 1.0; to this cluster of five species loosely links the *Medicago-Equisetum* species pair; and again, to this cluster of seven species such formed links, with a very low similarity value, the *Fumana-Euphorbia* species pair of very strong similarity value. In autumn, a cluster, consisting of a species pair (*Medicago-Thymus*), with similarity values between 2.0 and 1.5, takes form, and also two such clusters that consist of three species each. To the *Medicago-Thymus* species pair, at similarity values between 1.5 and 1.0, links the *Festuca*, and in this same region the former two clusters, consisting of three species each, fuse. Then, at the similarity values between 1.0 and 0.5, the clusters consisting of three and of six species also fuse.

Root depth

The root depth dendrograms (Figs 3 and 4) show not more similarity than that at values between 2.0 and 1.5 there can be found three clusters consisting of two species pairs, but these species pairs are not identical in autumn and summer. The dendrogram shows one species pair (*Fumana-Euphorbia*), and a cluster consisting of four species, at similarity values be-
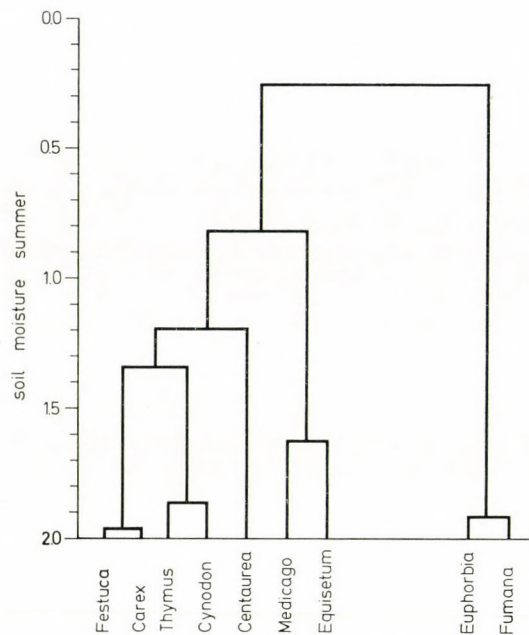
Fig. 1. Dendrogram of soil moisture content, summer
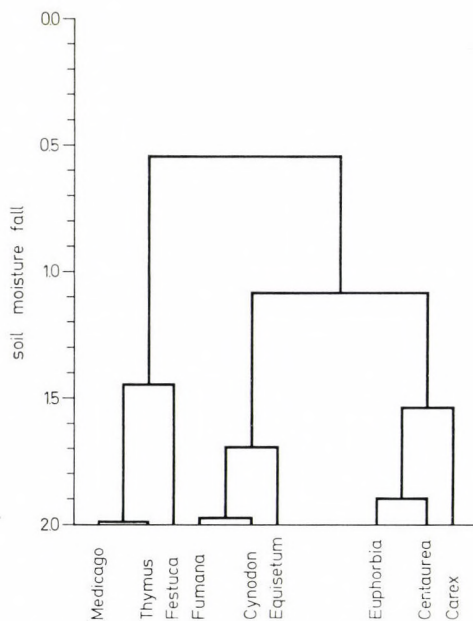
Fig. 2. Dendrogram of soil moisture content, autumn
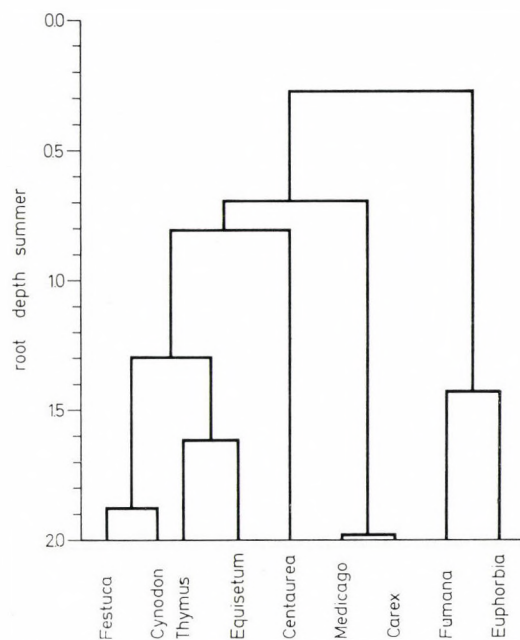
Fig. 3. Dendrogram of root depth, summer
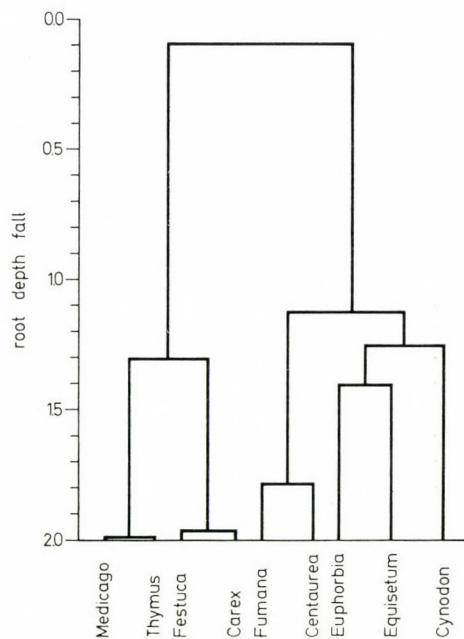
Fig. 4. Dendrogram of root depth, autumn
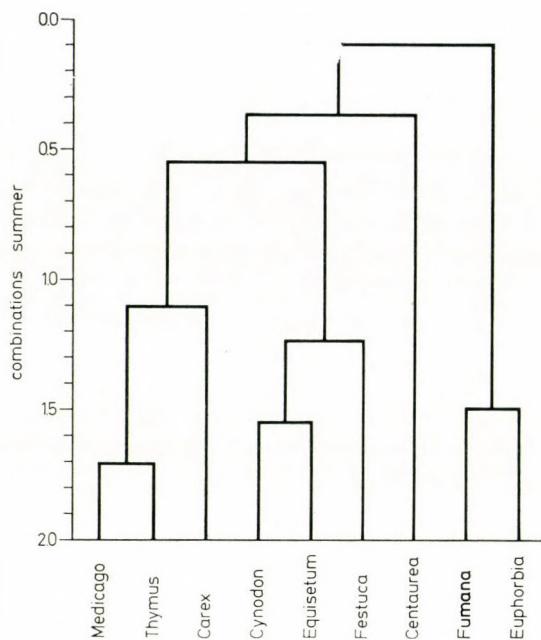
Fig. 5. Dendrogram of combination of soil moisture content and root depth, summer
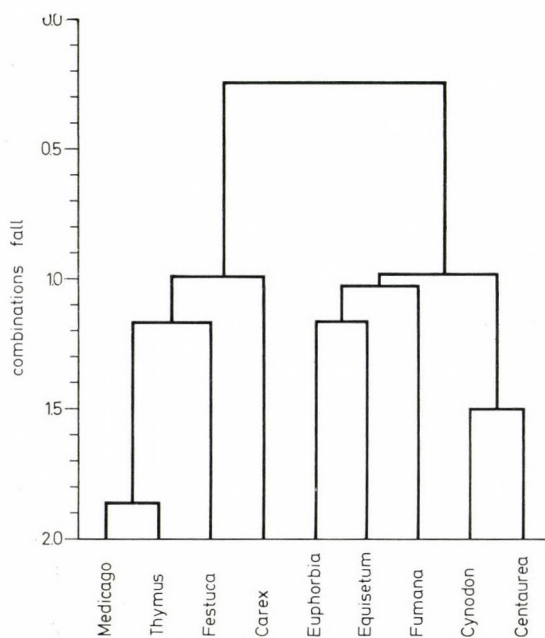
Fig. 6. Dendrogram of combination of soil moisture content and root depth, autumn

tween 1.5 and 1.0, in summer. In the next similarity category (1.0—0.5), *Centaurea* is the first to fuse with the four species clusters mentioned above, then comes the *Medicago-Carex* species pair. To the seven-membered cluster thus formed, loosely links the *Fumana-Euphorbia* species pair. In autumn, a great similarity value is shown by the *Medicago-Thymus* and the *Festuca-Carex* species pair. These four species fuse at similarity values between 1.5 and 1.0, and form a four-membered cluster which links only at the last fusion to the other five-membered cluster, which has taken form also in the similarity category with values between 1.5 and 1.0.

Combinations

The dendrograms show different pictures with regard to also the combination of soil moisture content and root depth (hereinafter: combinations; Figs 5 and 6). In the dendrogram compiled on the basis of summer measurements, there are three species pair to fuse, and again in the autumn measurements there are two, in the similarity category of 2.0—1.5. The *Medicago-Thymus* species pair emerges in this category in summer and autumn as well. The *Fumana-Euphorbia* species pair maintains its independence up to the last fusion in summer, and also *Centaurea* occurs separately up to the fusion before the last. In summer, in the similarity category of 1.5—1.0 there can be found two clusters consisting of three species, which fuse in the next category. In autumn, again there occur two three-membered clusters in the 1.5—1.0 similarity category, but these are constituted of other species than those found in the summer dendrograms. In the next similarity category, there occur a four- and a five-membered cluster.

Conclusions

The *Centaurea* and the *Fumana-Euphorbia* species pair in summer separate from the other species with regard to the two dimensions and also their combination. The different behaviour of *Fumana* from the other species has already been indicated in our former paper (Fekete et al. 1977). The fact, however, that *Euphorbia* behaves similarly to *Fumana* has been detected only now. Our attention to the separation of *Centaurea* has been called by the analysis.

On the basis of the dendrograms it seems that in autumn, at similarity values between 2.0 and 1.0 there are already greater clusters to form, while in summer they occur only at values lower than 1.0. This may be an indication that the requirements of species are more different in summer.

According to their structures, the dendrograms showed the following order: combinations, summer-autumn ($d = 0.379$); root depths, summer-

autumn ($d = 0.537$); and soil moisture content, summer-autumn ($d = 0.553$). Structurally, the dendrograms of the combinations are at most in the vicinity of one another.

In the table below, the distances between the structures of the combinations and of the dimensions are indicated:

soil moisture content		soil moisture content summer	soil moisture content autumn	root depth summer	root depth autumn
combinations	summer	0.417		0.339	
	autumn		0.408		0.237

For comparisons between the dendrograms, the chord distance was used. In the similarity categories mentioned above, the junctions were counted and, on the basis of the frequencies falling to the various categories, the chord distances were calculated. The two dendrograms are at most "similar" to each other between which the distance is the smallest.

The smallest value between the summer and autumn dendrograms of the individual dimensions occurred in soil moisture content ($d = 0.232$); then came the summer and autumn dendrogram of combinations ($d = 0.333$), while the greatest distance occurred between the two dendrograms of root depths ($d = 0.579$).

The dendrograms of combinations are nearer to those of root depths than to those of soil moisture content; see the table below:

soil moisture content		soil moisture content summer	soil moisture content autumn	root depth summer	root depth autumn
combinations	summer	0.539		0.471	
	autumn		0.671		0.493

The results can support the authors' earlier statement according to which the overlap picture by factor combinations is nearer to the overlap picture of root depth.

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SYSTEMATISCH-NOMENKLATORISCHE BEMERKUNGEN ÜBER KRITISCHE TAXA DER MITTELEUROPÄISCHEN FLORA

Von

R. Soó

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(Angekommen am 1. September, 1977)

As a continuation of his earlier studies (Acta Bot. Hung. 1963—1971, Annal. Univ. Budapest Sect. Biol. 1964—1972, with co-authors; and Feddes Repertorium 1972, 1974), the author presents his newer statements of taxonomy and nomenclature; these are stammed from the compiling of the 6th volume of Synopsis . . . Florae Vegetationisque Hungariae. Mention must be made of the new taxonomical evaluation of the saisonpolymorph ecotypes; of the surveying of certain critical form categories and aggregates, as regards especially the *Jovibarba hirta*, *Fraxinus angustifolia*, *Leucanthemum vulgare*, *Scilla bifolia* etc. groups.

Beschreibungen neuer Taxa, neue Namenskombinationen, mikrosystematische und geobotanische Bemerkungen usw., die im Laufe meiner Synopsis systematico-geobotanica habe ich seit 1963 in mehreren Studienserien mitgeteilt, so besonders «Species et combinationes novas florae Europae praecipue Hungariae I—X.» Acta Bot. Acad. Sci. Hung. **9—17.** (1963—1971) — als Ergänzung dazu «Nomina a nobis non rite publicata», ibidem **18.** 1972 — ferner »Über einige Formenkreise der ungarischen und karpatischen Flora I—XVIII.« mit verschiedenen Mitarbeitern, Annal. Univ. Budapest Sectio Biolog. **7—10., 12, 14.** (1964—1972) und Acta Bot. 1. c. 14. (1968). Die wichtigsten systematisch-nomenklatorischen Ergebnisse der Synopsis 1—5. (1964—1973) wurden im Feddes Repertorium **83.** 129—212, **85.** 433—453 (1972, 1974) zusammengefasst. Vorliegende Mitteilung ist eine Fortsetzung der genannten und bezieht sich auf solche Probleme, die während der Bearbeitung des Bandes 6. (im Druck) auftauchten. Hervorzuheben ist die neue Bewertung der saisonpolymorphen Ökotypen, ferner Besprechung gewisser Formenkreise bzw. Agg. der Gattungen *Jovibarba*, *Fraxinus*, *Leucanthemum*, *Scilla*.

Phyllitis Scolopendrium (L.) Newm. subsp. **antri-jovis** (Kümmerle Magy. Bot. Lap. **19:** 3, 192, 1922) Soó *comb. n.* (*Biropteris a.—j.* Kümmerle 1. c., *Asplenium Scolopendrium* L. subsp. *a.—j.* Brownsey et Jermy Brit. Fern. Gaz. **10:** 341—346, 1973).

Dryopteris austriaca (Jacq. 1764 sub *Polypodio*) Woynar, nach H. P. Fuchs in Janchen Catal. Fl. Austriae 897, 1960 und in Soó Syn. Fl. Veg. Hung. **1:** 546, 1964, nach dem Original von Jacquin ist *Pteridium aquilinum* var. *lanuginosum*, dagegen schreibt Jermy (Brit. Fern. Gaz. **10:** 106, 1973), daß

in Wien kein Original von JACQUIN vorhanden ist, ein Exemplar in London (»mont. Hungaricis«) — von der Grösse abgesehen — der Beschreibung von JACQUIN entspricht für Lectotypus annehmbar und *D. dilatata* ist. Seitdem gebrauchen manche (wie RAUSCHERT 1975) den Namen *D. austriaca* für *D. dilatata*. Meiner Meinung nach ist *D.* bzw. *Polypodium austriacum* nom. dubium.

Larix decidua L. Bobrov Nov. syst. plant. vasc. **9.** (1972) will *L. polonica* Racib. 1912 für introgressive Hybridart von *L. decidua* und *sibirica* betrachten, doch kommen der polnisch und ostkarpatisch »*L. polonica*« vollkommen identischen Exemplare mit kleinen Zapfen und Übergänge auch in anderen karpatischen und alpinen Populationen vor, wie ich darauf schon 1932 (Bull. Soc. Bot. Fr. **79:** 658—659) hingewiesen habe. Vgl. auch Soó Feddes Rep. **83:** 176, 1972.

Asplenium cuneifolium Viv. 1806 Die Unterarten sind: subsp. *cuneifolium*, subsp. *serpentini* (Tausch 1839) Soó 1972 (subsp. *Forsteri* (Sadler 1820) Borb. 1887), subsp. **dacicum** (Borb. Term. tud. Közl. Pótf. **46:** 71, 1898 p. sp.) Soó *comb. n.* aus Siebenbürgen. Nach beweisenden Argumenten ungarischer Botaniker (BORBÁS Vasmegye növényf. 1887: 540, ebenso l. c. 1898, KÜMMERLE Schedae Fl. Hung. Exs. **4:** 22—25, 1916, JÁVORKA 1924, Soó 1964, sind die Pflanzen Italiens (Genova, Orig. von VIVIANI!) und Österreichs (Burgenland!!) gar nicht identisch. Vgl. auch Soó Feddes Rep. **83:** 141, 1972.

Ranunculus auricomus agg. Die aus Thüringen beschriebene, aber auch aus Ungarn und Siebenbürgen mitgeteilte *R. vertumnalis* O. Schwarz Mitt. Thür. Bot. Ges. **1:** 124—5, 1949 icon.! ist bestimmt *R. binatus* Kit.

Asarum europaeum L. subsp. *caucasicum* (Duchartre 1864) Soó 1966 dazu Syn.: var. *Andreanszkyi* Pénzes 1939, var. *pseudocaucasicum* Pawl. 1956, vgl. die neuen Arbeiten von STEINHÜBL (1971), SCHÖNFELDER (1973), SEYBOLD (1974).

Platanus hispanica Muenchhausen 1770 (*P. hybrida* Brot. 1804, *P. acerifolia* Ait. 1789. p. var.) Willd. 1805) Unsere Platan ist wohl mit der *P. orientalis* verwandte uralte mediterrane Art, nicht hybridogen. Vgl. die Discussion in Acta Agronom. Hung. 1976 über die Mitteilung von RADICS.

Rubus rhombifolius Wh. et N. (*argenteus* auct.) subsp. **consobrinus** (Sudre Rub. Pyr. 46, 1899 p. sp.), subsp. **cryptadenes** (Sudre Obsr. Brit. Rub. 31, 1904 p. sp.), subsp. **callimorphus** (Sudre l. c.) subsp. **connatifolius** et subsp. **racemosus** (Nyár. Fl. RPR. 4: 909, 1956 sub R. argenteo) Soó *comb. n.*

R. stenopetalus P. J. Muell. et Lej. 1859 (*R. chloocladus* Watson 1956) subsp. **aduncispinus** (Sudre Rubi Eur. 86, 1910 p. subsp. *R. pubescentis*), subsp. **emollitus** (Sudre Rub. Pyr. 56, 1900 p. sp.) Soó *comb. n.*

R. candicans Wh. ex Rchb. 1832 subsp. **tumidus** (Gremli Beitr. z. Fl. Schw. 30, 1870 p. sp.) Soó subsp. **aciodontus** (P. J. Muell. et Lefévre Pollichia **16—17:** 83, 1859 p. sp.) Soó *comb. n.*
R. micans Gren. et Godr. 1849 subsp. **albicomus** (Gremli Beitr. z. Fl. Schw. 30, 1870 p. sp.) Soó *comb. n.*
R. Koehleri Wh. et N. 1825 subsp. **pygmaeus** (Wh. et N. ex Bluff et Fingerhut Consp. Fl. Germ. 1: 687, 1825 p. sp.) Soó *comb. n.*
R. tereticaulis P. J. Muell. 1856 subsp. **miostylus** (Boulay Ronces Vosg. 1868: 105, p. sp.), subsp. **fragariiflorus** (P. J. Muell. Flora **41:** 173, 1858, p. sp.) Soó *comb. n.*
R. morifolius P. J. Muell. ssp. **condensatus** (P. J. Muell. Flora **41:** 167, p. sp. 1858) Soó comb. n.
R. amoenus Koehler ex Wh. ssp. **praedatus** (Schmidely Bull. Herb. Boiss. **2:** 79, 1903 p. sp.) Soó comb. n.
R. schleicheri Wh. ex Tratt. 1823 subsp. **coeruleicaulis** (Sudre Bull. Soc. Sc. Angers **35:** 47, 1906 p. sp.) Soó *comb. n.*
R.. **rivularis** Wirtgen et P. J. Muell. 1859 — subsp. **angustisectus** (Sudre Bull. Acad. Géogr. Bot. **15:** 231, 1905), subsp. **parvulipetalus** (Sudre Bull. Soc. Sci. Angers **35:** 39, 1906 p. sp.), subsp. **lamprophyllus** (Gremli Öst. Bot. Zschr. **21:** 94, 1871 p. sp.), subsp. **biserratus** (P. J. Muell. ex Boulay Ronces Vosg.: 115, 1868 p. sp.), subsp. **horridulus** (P. J. Muell. ex Boulay l. c. 112, 1868 p. sp.), subsp. **leptobalus** (Sudre Bat. Eur. 31, 1904 p. sp.), subsp. **durotrigum** (R. P. Murray Journ. Bot. **30:** 15, 1892) Soó *comb. n.*
R. serpens Weihe ex Lej. et Court. 1831 subsp. **longisepalus** (P. J. Muell. Bonplandia **9:** 297, 1861 p. sp.), subsp. **obrosus** (P. J. Muell. Pollichia **16—17:** 234, 1859 p. sp.), subsp. **analogus** (P. J. Muell. Pollichia l. c. 232), subsp. **humorosus** (P. J. Muell. Vers. Mon. Rub. 1859: 156 p. sp.), Soó *comb. n.*
R. hirtus W. et K. 1805 subsp. **Pierratii** (Boulay Ronces Vosg. 1868: 108 p. sp.), subsp. **offensus** (P. J. Muell. Bonplandia **9:** 286, 1861 p. sp.), subsp. **anoplocladus** (Sudre Bull. Soc. Bot. Fr. **52:** 337, 1905 p. sp.), subsp. **minutidentatus** (Sudre l. c. 323, 1905 p. sp.), subsp. **rubiginosus** (P. J. Muell. Pollichia **16—17:** 207, 1859 p. sp.), subsp. **interruptus** (Sudre Bull. Ass. Fr. Bot. **2:** 7, 1899 p. sp.), subsp. **trachyadenes** (Sudre Compt. Rendus Congr. Soc. Sav. 1908: 233 p. sp.), subsp. **anisacanthoides** (Sudre Bull. Soc. Bot. Fr. **52:** 328, 1905 p. sp.), subsp. **declivis** (Sudre Compt. Rendus l. c. 1908: 233 p. sp.) Soó *comb. n.*

Potentilla impolita Wahlbg. 1814 em. Soó 1963 (*P. neglecta* Baumg.), Manche neueren Autoren bezweifeln die Identität der beiden Taxa, aber unrecht. Simonkai (Erdély fl. 1887, p. 219) schrieb »Baumgartenius nam non solum citationem *Pot. impolitae* Wahlenbg., sed etiam diagnosim illae ad suam stirpem descripsit«. *P. neglecta* ist also illegitime Neubenennung von *P. impolita.*

P. argentea agg. Weitere Kleinarten (Agamospecies): **P. pseudocalabra** (Th. Wolf Mon. Pot. 208, 1908 p. var. *P. argenteae*) et **P. tenerrima** (Velen. Fl. Bulg. Suppl. **1:** 102, 1898 p. var. *P. colliane*) Soó *comb. n.* (Borhidi 1965 p. subsp.).

P. inclinata Vill. 1788 em. Ball et Walters var. **adscendens** (W. et K. ex Willd. En. horti Berol. **1:** 554, 1809 p. sp.), var. **hungarica** (Willd. Magaz. Natur. Freunde Berlin **7:** 289, 1813 p. sp., in Borb. Balaton 1900: 428 p. var. *P. adscendentis*), var. **fallax** (Uechtr. Jb. Schles. Ges. Vaterl. Kultur **44:** 81, 1863 p. var. *P. canescentis*) — incl. *P. Baumgarteniana* Schur 1866, Simk. 1887 p. subsp. *P. canesc.* —, var. **leopoliensis** (Blocki Öst. Bot. Zschr. **37:** 334, 1887 p. sp., A. et G. Syn. VI. 2: 708, 1904 p. var.) Soó *comb. n.*

Alchemilla monticola Opiz var. **hungarica** (Soó Acta Bot. Hung. 9: 424, 1963 p. sp.) Soó *comb. n.* (*A. plicata* auct. hung., sic Palitz Acta Geobot. Hung. **1:** 112, 1936, Soó Feddes Rep. 40: 767).

Combinationes novae Rosarum:

R. caesia Sm. ex Sow. 1812 var. *coriifolia* (Fries Novit. Fl. Sueciae **33.** 1814 p. sp.), f. *oblonga* (Christ Rosen Schw. 191, 1875 p. f. *R. coriif.*), var. *trichostylis* (Borb. Mon. Ros. Hung. 1880: 438 p. f. *R. coriif.*), var. *psammophila* (Borb. ex Hollós Kecskemét fl. 107, 1896 p. sp.), var. *lucida* (Bräucker Deutschl. Rosen 1882: 69 p. f. *R. coriif.*), var *subbiserrata* (Borb. l. c. 439 p. f. *R. coriif.*), f. *Eschfälleri* (Wiesb. ex J. B. Keller ÖBZ. **33:** 377) — II. 242 unrichtig *Eschfälleriana* —, var. *frutetorum* (Bess. Catal. pl. Horti Crem. Suppl. III: 20, 1811 p. sp.), ssp. **subcollina** (Christ 1873) Soó 1971 var. *incana* (Kit. ex Schult. Oest. Fl. II. 70, 1814 p. sp.), var. *pusztarum* (Deg. ex Jáv. l. c. 580 p. f. *R. coriif.*, 1924).

R. livescens Bess. 1815 var. *Jundzilliana* (Christ Flora **60:** 405 p. f. *R. trachyphyllae*), f. *tolnaensis* (Borb. et Wiesb. in Borb. Mon. Ros. Hung. 384, 1880), f. *aseticlados* (Borb. l. c. 377 p. f. *R. Jundzillii*), var. *nemorivaga* (Dés. Billotia **1:** 40, 1864 p. sp.), var. *alsatica* (H. Br. Verh. ZBG. **35:** 72 1885 p. var. *R. trachyphyllae*), ssp. **trachyphylla** (Rau En. Ros. Wirceb. 124, 1816 p. sp.), f. *Schmidtii* (H. Br. l. c. 72 p. sp.), f. *reticulata* (Kern. ÖBZ **19:** 332 1869 p. sp. — in II. 230 erroneo »Borb.«) var. *leioclada* (Borb. l. c. 378, 1880 sub. *R. Jundzillii*), var. *Grundliana* (Deg. ex Jáv. Magy. Fl. 550, 1924 p. var. *R. Jundzillii*), var. *cremsensis* (J. Kern. in Beck. Fl. N. Öst. 805, 1892 p. var. *R. trachyphyllae*), var. *Trautmanni* (Deg. ex Jáv. l. c. 1924), var. *speciosa* (Dés. Billotia **1:** 39, 1864 p. sp.), var. *heteracantha* (Christ Rosen Schw. 144, 1873 pro f. *R. Jundzillianae*), var. *minor* (Borb. l. c. 375, 1880 p. var. *R. Jundzillii*) . . . Soó.

R. corymbifera Borkh. 1790 var. *platyphylla* (Rau En. Ros. Wirceb. 82, 1816 p. sp.), var. *sphaerocarpa* (Puget ex Dés. Soc. Bot. Belg. **15:** 377, 1876 p. sp.), var. *platyphylloides* (Chab. ex Dés. et Ripart Soc. Bot. Belg. 15: 376, 1876

p. sp.), var. *Reussii* (H. Br. Verh. ZBG. **35:** 104, 1885 p. sp.), var. *obscura* (Puget ex Dés. l. c. 374, 1876 p. sp.), var *semiglabra* (Ripart ex Dés. l. c. 373, 1876 p. sp.) var. *urbica* (Leman Bull. Soc. Phil. 1818: 93 p. sp.), var. *ramealis* (Puget ex Dés. l. c. 372, 1876 p. sp.), var. *globata* (Dés. l. c. 374, 1876 p. sp.), var. *peropaca* (H. Br. Ber. Bot. Ver. Landshut 1889: 107) var. *hirta* (H. Br. ex Oborny Fl. Mähren 908, 1886), var. *urbicoides* (Crép. Soc. Bot. Belg. 8: 240, 1869 p. sp., nom. nud. ex H. Br. in Beck l. c. 797), var. *trichoneura* (Ripart ex Dés. l. c. 375, 1876 p. sp.), var. *submitis* (Gren. ex Billot Schultz Arch. 1852: 332 p. sp.), var. *leptotricha* (Borb. l. c. 430 p. var. *R. dumetorum*, 1880), var. *Brachtii* (H. Br. ÖBZ **44:** 20, 1894 p. sp.), var. *Walziana* (Borb. ÖBZ. **41:** 423 p. sp.), var. *incanescens* (H. Br. ex Kern. Schedae FEAH. **5:** 15, 1888 p. sp.), var. *cinerosa* (Dés. l. c. 380, 1876 p. sp.), var. *Rocheliana* (H. Br. ex Kern. l. c. 1888 p. sp.), var. *subglabra* (Borb. l. c. 426, 1880, Budapest fl. 1879: 161 p. var. *R. dumetorum*), var. *semiglauca* (Borb. l. c. 1880, et 1879 nom. seminudum, p. var. *R. dumetorum*), var. *juncta* (Puget ex H. Br. ZBG. **38,** 1887: 64 p. ssp. *R. uncinellae*), var. *decalvata* (Crép. ex H. Br. in Beck Fl. NÖ. 800. 1892 p. var. *R. dumetorum*), var. *Annoniana* (Puget ex H. Br. Verh. ZBG **35:** 95, 1885 p. sp.), var. *rivularis* (H. Br. et Borb. in Kern. Schedae FEAH. **5:** 110, 1645, 1888 p. sp.), var. *eulanceolata* (H. Br. ex Kern. l. c. 1888 p. sp.), var. *heterotricha* (Borb. Mon. Ros. Hung. 426, 1880 p. f. R. *dumetorum*), var. *ciliata* (Borb. l. c. 427 p. f. *R. uncinellae*), var. *hemitricha* (Ripart in Dés. Soc. Bot. Belg. **15:** 373, 1876 p. sp.), var. *suboxyphylla* (Borb. l. c. 427 p. f. *R. dumetorum*), var. *subatrichostylis* (Borb. l. c. 427 p. f. *R. dumetorum*), var. *quadica* (H. Br. Ber. Bot. Ver. Landshut 1889: 108 p. f. *R. dumetorum*), var. *amblyphylla* (Ripart in Dés. l. c. 380, 1876 p. sp.), var. *Aemoniana* (Puget ex R. Keller in A. et G. Syn. VI. 1: 182, 1902 p. var. *R. dumetorum*) . . . Soó var. *solstitialis* (Bess. 1809) und var. *uncinella* (Bess. 1809) Chrsanovszki 1954 ssp. **Deseglisei** Bor. 1857 var. *hispidula* (Ripart ex Dés. l. c. 386, 1876 p. sp.), var. *incerta* (Dés. l. c. 384, 1876 p. sp.), var. *imitata* (Dés. Mém. Soc. Acad. Maine- et Loire **28:** 120, 1872 p. sp.), var. *trichoidea* (Ripart in Dés. Soc. Bot. Belg. **15:** 386, 1876 p. sp.), var. *denticulata* (Borb. l. c. 388 p. f. *R. collinae* 1880)? — anne hybrida —, var. *Györffyana* (Deg. ex Jáv. Magy. Fl. 565 p. var. *R. dumetorum* 1924)

R. dumalis Bechst. 1810 var. *Afzeliana* (Fries Fl. Halland. 87, 1818 p. sp.) var. *falcata* (Puget Mém. Soc. Acad. Maine- et Loire **28:** 106, 1875 p. sp.), var. *Graveti* (Crép. Bull. Soc. Bot. Belg. **30:** 156, 1891 p. sp.), var. *pilosula* (Christ Flora **58:** 295, 1875 p. f. *R. Reuteri*), var. *subcoerulescens* (Borb. l. c. 465 p. f. *R. alpestris*), var. *Holubyana* (Borb. l. c. 465 p. f. *R. alpestris*), var. *acutifolia* (Borb. l. c. 445 p. f. *R. glaucae*), var. *complicata* (Gren. Fl. Jurass. 293, 1864 p. sp.), var. *caballicensis* (Puget ex Dés. Billotia **1:** 35, 1864 p. sp.) subsp. **subcanina** (Christ 1873) Soó 1971 var. *atroviridis* (Borb. l. c. 444 p. f. *R. glaucae*), var. *diodus* (R. Kell. in A. et G. l. c. 197 p. var. *R. glaucae*), var.

subleiostylis (Borb. l. c. 444 p. f. *R. glaucae*), var. *brachypoda* (R. Keller Synopsis Rosarum . . . 1931 p. var. *R. glaucae*)

Jovibarba hirta (Jusl.) Opiz typisch in Ungarn selten, subsp. **borealis** (Huber in Hegi Fl. Mitteleur. ed. 4. IV. **2:** 197, 1963 sub *Diopogone*) Soó *comb. n.* [*J. sobolifera* (Sims.) Opiz 1852] Übergänge der beiden früher als Arten aufgefassten Taxa: *J. hirta* subsp. *glabrescens* (Sabr.) Favarger et Zeisiger 1964. Weitere Unterart: subsp. **Preissiana** (Domin Rozpr. Česk. Akad. 42, no. **29:** 19, 1932 als *Sempervivum P.*) incl. var. *tatrensis* (Domin) Soó 1972. — Wenn man *J. sobolifera* als eigene Art betrachtet, zieht man dazu die siebenbürgische Rasse: subsp. *hirtella* (Schott) Soó 1972 (*Semperv. Simonkaianum* Degen 1902, vgl. Soó Scripta Mus. Transs. **1:** 45, 1942) resp. *J. hirta* subsp. **hirtella** (Schott ex Fuss Verh. Siebenb. Ver. **7:** 171, 1857 sub *Sempervivo*) Soó *comb. n.*, sie stellt einen Übergang zwischen *J. sobolifera* u. *J. arenaria* (Koch) Opiz dar.

Chamaecytisus ratisbonensis (Schaeffer) Roth. var. **microphyllus** (W. et Gr. Fl. Siles. II. 2: 250, 1829) Soó comb. n.

Lotus corniculatus agg. Žertová (Rozpr. ČS. Akad. Ved. Mat.—Prir. **82:** 3, 1973) hat die Arbeiten von Borsos kaum berücksichtigt, var. *ciliatus* wird überflüssig auf var. *Kochii* umgetauft, ssp. *major* (Scop.) Gams var. *colocensis* (Menyh. 1877) Borsos 1966 ist nach ihrer Meinung mit var. *sativus* Hyl. ex Jalas 1950 identisch (? ?). Subsp. *Preslii* Ponert 1973 = subsp. *procumbens* (Poir.) Briq. 1913.

Vicia Cracca L. Übergang (transitus) zu *V. tenuifolia* ist die diploide (2n: 14) *V. Kitaibeliana*, von Löve für eigene Art anerkannt. Besser subsp. **Kitaibeliana** (Rchb. Fl. Gern. exs. no. 768, 183, 1832 p. sp. em. A. et D. Löve) Soó *comb. n.* (*V. C.* var. *linearis* Peterm. 1838 ?, var. *transiens* Soó 1939!!)

Cornus sanguinea L. subsp. **australis** (C. A. Mey. Ann. Sc. Nat. 3. sér. **4:** 69, 1865 p. sp.) Soó *comb. n.*, Jáv. 1924 comb. incerta.

Caucalis platycarpos L. subsp. **Bischoffii** (Kozo-Polj. Bull. Soc. Nat. Moscou **29:** 153, 1916 p. sp.) Soó *comb. n.* (subsp. *muricata*) (Bischoff non Cr.!) Heywood 1962).

Sium Sisarum L. ssp. **sisaroideum** (DC. Prodr. 4: 124 p. sp. 1830) Soó comb. n.

Heracleum Sphondylium L. subsp. **carpaticum** (Porcius Magy. Növ. Lap. **2:** 25, 1878 p. sp.) Soó *comb. n.*

Cruciata glabra (L.) Ehrend. subsp. **balcanica** (Ehrend. Bot. Linn. Soc. **66:** 272, p. sp.) Soó *comb. n.*

Galium album Mill. var. **stenophyllum** (Schur En. plant. Transs. 1866: 284, p. var. *G. lucidi*), var. **transsilvanicum** (Schur l. c. 283, 1866), var. **petraeum** (Schur l. c. 284, 1866) Soó *comb. n.* (Syn.: *G. erectum* var. *Bielzii* (Schur, Simk. 1887 basion. illeg.) alle aus Siebenbürgen.

Valeriana officinalis agg. Dazu als Kleinarten 2n: 56; **V. excelsa** Poir. (*V. sambucifolia* Mikan f.), **V. repens** Host (*V. sambucif.* subsp. *procurrens* Soó 1965 resp. **V. off.** subsp. **procurrens** (Wallr. Linnaea **15:** 540, 1840 p. sp.) Soó *comb. n.* 2: 14; **V. officinalis** L. s. str. mit subsp. *Sarkanyii* (Soó 1958) A. et D. Löve 1961 (schmalblättrig); 2: 28; **V. stolonifera** Czerniajew 1845 em. Soó [*V. off.* subsp. *collina* (Wallr. 1840) Nym. 1879] incl. subsp. *angustifolia* (Tausch ex Host 1827) Soó 1972 mit subsp. *intermedia* (Peterm. 1838) Soó 1972 (*V. off.* subsp. *interm.* A. et D. Löve 1961, breitblättrig), **V. nitida** Kreyer 1924 (*V. off.* subsp. *nitida* Soó 1958, incl. *V. off.* subsp. *pratensis* (Dierbach 1827 p. var. E. Walther 1949 p. sp. non Benth. ex Steud 1841) Soó 1958.

Scabiosa triandra L. 1753 (*S. gramuntia* L. 1762) subsp. **agrestis** (W. et K. Plant. rar. Hung. **3:** 226, 1805 p. sp.) Soó *comb. n.*, var. **tomentosa** (Vitman Summa plant. 1789: ? p. sp.), var **mollis** (Willd. Enum. Horti Berol. Suppl. 7, 1813 p. sp.) Soó *comb. n.*
S. Columbaria L. Richtige Autoren der Unterarten: subsp. *pseudobanatica* (Schur) Jáv. ex Jáv. et Csapody 1933, subsp. *banatica* (W. et K.) Diklič 1973, Soó 1974. Die beiden sind nicht identisch, wie in der Fl. Eur. **4.** 496 steht, erstere im Ungar. Mittelgebirge und in Ostkarpaten, (Österreich?), letztere Südrumänien, Bulgarien, Jugoslawien.

Tilia tomentosa Moench 1785 (*T. argentea*) subsp. **petiolaris** (Petzold et Kirchner Arb. Musc. 162, 1864 p. var.) Soó *comb. n.* bzw. *petiolaris* (DC. 1824 nom. dub.) Soó in Rauh et Senghas »Schmeil-Fitschen« Flora ed. 81, 1968, nom. illeg.

Euphorbia villosa W. et K. ex Willd. 1800 subsp. **carpatica** (Wol. Spraw. Kom. Fizyogr. **27:** 153, 1892 p. sp.), subsp. **valdevillosocarpa** (Arv. et Nyár. Bul. Grad. Bot. Cluj. **15:** 190, 1935 p. sp.), subsp. **austriaca** (Kern. Öst. Bot. Zschr. **25:** 397, 1875 p. sp.) Soó *comb. n.* Keine endemische Kleinart der NO-Alpen, auch in den Nordkarpaten bis Ukraine.
E. dulcis L. subsp. *incompta* (Cesati 1838) Nym. 1878 (*E. purpurata* Thuill.) Aus Ungarn habe ich nur die Unterart gesehen.
E. virgata W. et K. 1803! non Desf. 1804 (*E. Tommasiniana* auct., *E. Waldsteinii* Soják 1972, Umtaufung überflüssig)
E. glareosa Pall. ex M. B. 1808 (*E. pseudoglareosa* Klokov 1955) ist die osteuropäische, *E. nicaeensis* All. 1785 die W-SW-europäische Art, unsere Pflanze können wie als *E. glareosa* subsp. *pannonica* (Host 1831) Kuzmanov 1961, besser als Kleinart zu behandeln.

Fraxinus angustifolia Vahl 1804 subsp. **pannonica** Soó et Simon 1940 (*F. oxycarpa* auct. Eur. mediae non Willd., *F. angustif.* subsp. *danubialis* Pouzar 1972, *F. Ptacovskyi* Domin 1937, *F. Pojarkoviana* Wassiljew 1952, *F. slavonika* (Majerszky 1914 nom. nud.) Haracsy 1975 nom. illeg. incl. subsp. *illyrhungarica*, *pannonica* und *euhungarica* nom. nuda) Die systematische Stellung der pannonischen Esche haben folgende Autoren mehr oder minder richtig erkannt: Soó et SIMON Acta Bot. Hung. **6.** 1960, FUKAREK Glasnik na sumske pokuse **14.** 1960, WASSILJEW Fl. SSSR. **18.** 1952, VISJULINA Fl. URSR. **8.** 1957, KÁRPÁTI Feddes Rep. **81.** 1970. Dagegen ist die Auffassung von FRANCO et ROCHA ALONSO (Bot. Journ. Linn. Soc. **61.** 1971 und Flora Europaea **3:** 54) ganz verfehlt, die von ihnen als identisch genannten Arten *F. angustifolia* und *F. oxycarpa* gehören sogar, wie ich schon 1960 geschrieben habe, zu verschiedenen Sektionen, erstere besitzt unverzweigten Blütenstand Aehre (botrys), zweitere eine verzweigte Rispe (panicula), vgl. KÁRPÁTI l. c. Der von JANCHEN benützte Name *F. parvifolia* Lam. 1786 (Encyl. Bot. **2:** 546) ist ganz unsicher. HARACSYS Mitteilung (Erdő 1975) ist ganz unwissenschaftlich, Verfasser kennt die Nomenklaturregel nicht.

Cuscuta scandens Brot. subsp. **Cesatiana** (Bert. Fl. Ital. **7:** 623, 1847 p. sp.) Soó *comb. n.*

Lappula marginata (M. B.) Gürcke subsp. **patula** (Lehm. Asperif. 124, 1818 p. sp. sub *Echinospermo*) Soó *comb. n.*

Calamintha transsilvanica (Jáv.) Soó *comb. n.* (*Satureja Brauneana* (Hoppe) Jáv. f. *transs.* Jáv. Bot. Közl. **20:** 150, 1922) Microspecies agg. *C. Nepeta*, uti *C. subisodonta* Borb. 1892 =? *C. Einseleana* F. Schultz 1850

Origanum vulgare L. var. **hirtum** (Schur En. pl. Transs. 524, 1866 p. var. *O. megastachyii*) Soó *comb. n.* (ssp. *barcense* (Simk.) Jáv. ex Borhidi 1968)

Thymus pannonicus All. em. Ronn. subsp. **auctus** (Lyka Bot. Közl. **20:** 145, 1924 p. subsp. *Th. Serpylli* s. str. Soó Acta Bot. Hung. **12:** 120 p. subsp. *Th. Marschalliani* Soó em. (formae omnes glabrescentes), nomen validum. Der älteste und gültige Unterartname für »*Th. Marschallianus* auct. eur. mediae non Willd.«, die Pflanze WILLDENOWS stammt aus der Krim (SCHMIDT 1969), die Auffassung von MACHULE und anderer ist unrichtig. — var. *calvifrons* (BORB. et H. BR. Vas megye fl. 215—218, 1887 p. var. *Th. Marsch.*) Soó *comb. n.* (*Th. Marschallianus* var. *Marsch.* auct.), ältester Varietätsname.

Solanum Dulcamara L. subsp. **pusztarum** (Soó Acta Bot. Hung. **12:** 356, 1966 p. var.) *comb. n.* Psammophiler Ökotyp. Charakterpflanze der Sandsteppen Mittelungarns (*Festucion vaginatae*, *Junipero-Populetum*).

Pseudolysimachion spurium (L.) Opiz var. **croaticum** (Borb. Balaton fl. 378, 1900 p. sp. sub *Veronica*), var. **australe** (Schrad.) Comment. Veron. **24,** 1803 p. sp. sub *Veronica*), var. **brevifolium** (W. et K. ex M. B. Fl. Taur.-Cauc. **1:** 6, 1808 p. sp. sub *Veronica*), var. **nitidum** (Ehrh. ex Hoffm. Comment. soc. Goetting. cl. math . . . **15:** 114, 1803 p. sp. sub *Veronica*) Soó *comb. n.* — **P. longifolium** (L.) Opiz var. **salicifolium** (Wallr. Schedae crit. 1822, 8 sub *Ver.*), var. **geniculatum** (Host Fl. Austr. **1:** 4, 1827 p. sp. sub *Ver.*), var. **cordifolium** (Wallr. l. c. 1822), var. **incisum** (Peterm. Anal. Pfl. schl. Fl. Leipzig 320, 1846 sub *Ver.*), var. **glabrum** (Ehrh. ex Schrad. Comment. Veron. **24.** 1803, p. sp. sub *Ver.*), var. **medium** (Schrad. l. c. **23,** 1803 p. sp. sub *Ver.*), var. **puberulum** (Benth. ex DC. Prodromus **10:** 466, 1846 sub *Ver.*) Soó *comb. n.* **P.** × **Mauksii** (Hulják Magy. Bot. Lap. **28:** 26, 1929 sub *Veronica*) Soó *comb. n.* — **P.** × **decipiens** (Nyárády Kolozsv. fl. 479, 1943 sub *Veronica*) Soó *comb. n.* Diagnosis latina (ap. Nyárády tantum hungarica): Laciniae corollae lanceolatae, partim apice revolutae. — *P.* × *Sooianum* (Borsos 1967 sub *Ver.*) H. W. Schmidt 1976

Melampyrum, Rhinanthus, Odontites, Euphrasia Die Existenz und systematische Bewertung der saisonpolymorphen Taxa wird auch in der neuesten Zeit stark diskutiert. Schon viel früher wurde Ihr Dasein bezweifelt oder verneint (Heinricher, Beauverd), andere (kürzlich Jalas, Smith) fanden die nordischen Populationen des *M. pratense* nicht auf bestimmte Ökotypen gut zertrennbar. Die Ausgabe 1976 der Flora von Rothmaler blieb bei der Bewertung subsp., Hartl (in Hegi 1972), Mayer, Niklfeld betrachten sie als Varietäten, bei *Euphrasia* (wo Yeo und Hartl viele frühere Arten vereinigt haben) sogar nur als Formen. Die vererblichen Ökotypen und die modifikativen Ökomorphosen sind oft kaum voneinander zu unterscheiden, die meisten Taxa sind noch genetisch kaum untersucht und ihre Konstanz nicht bewiesen. Nachdem die saisonpolymorphen Rassen als Ökotypen von den wirklichen, geographisch bedingten Unterarten mit eigenem Areal in der Tat sich unterscheiden und minderen systematischen Wertbesitzen, bezeichne ich sie künftig als »proles«, eine früher oft gebrauchte, heute nicht »offizielle« Rangstufe, so kann man sie entweder für subsp. oder für var. halten, doch ist ihre systematische Stellung ganz andere und höhere, als die der »üblichen« Varietäten, deren Charakteristik ich schon 1926—27 (*Melampyrum* Monographie) pünktlich beschrieb. Die Autorennamen können die der subsp. — bleiben.

M. bihariense Kern. prol. **romanicum** (Borza Bul. Grad. Bot. Cluj. **1:** 19, 1921 pro subsp. *M. nemorosi*) Soó *comb. n.* (Aelterer Unterartname, als *Römeri* (Ronn.) Soó 1927)

M. pratense agg. ist am besten in Kleinarten mit geographischen Unterarten und Ökotypen zu teilen, kurz zusammengefasst: 1. *M. pratense* L. — dazu subsp. *commutatum* (Tausch) Britton (*vulgatum*), *angustifrons* (Borb. 1888)

Soó 1927 —, von Frankreich über die Alpen bis Jugoslavien, fehlt in den Karpaten, dagegen ist *oligocladum* (Beauv. 1916) nur proles — *alpestre* (Brügger 1874) Ronn. 1910, *tatrense* Soó, 1927 *Engleri* Soó 1927, *monticola* (Beauv. 1916) Soó 1939, *paradoxum* (Dahl ex Hay. 1905) Ronn. 1910 — 2. *M. paludosum* (Gaud. 1829) Ronn. 1914 (Soó 1927 p. subsp.) — 3. *M. congestum* (Beauv. 1916) Soó 1972 (subsp. 1927) — 4. *M. purpureum* (Hartm. 1820) Soó 1972 (1927 p. subsp.), incl. prol. *purpurescens* (Asch. 1898) Soó 1972 — 5. *M. montanum* Johnston 1829 (*M. hians* (Druce 1885) Soó 1972) incl. prol. **hians** (Druce Naturalist **10:** 35, 1885 p. forma) Soó *comb. n.*, subsp. **scotianum** (Beauv. Mon. Melamp. 1916: 486 p. subvar.) Soó *comb. n.* (Britton 1943 p. subsp.) — 6. *M. chrysanthum* (Beauv. 1911) Hess et Landolt Fl. Schw. **3:** 778, 1972.

Rhinanthus angustifolius C. C. Gmel. 1806 ist wohl der älteste glütige Artname, wurde aber im Laufe der Zeit von vielen Autoren in ganz verschiedenem Sinne gebraucht, deshalb nom. confusum. Ich nehme die Beweise von Rauschert und Gutermann (beide 1975) an, der gültige Name ist **Rh. serotinus** (Schönheit) Oborny em. Hyl. Als agg. umfaßt die Taxa subsp. *serotinus*, die in Ungarn fehlt (dazu am nächsten steht proles. **Lykae** (Soó Feddes Rep. **26:** 201, 1929 p. subsp. *Rh. maj.*), — subsp. *grandiflorus* (Wallr. 1822) Janchen 1960 mit prol. *vernalis* (Zinger) Hyl., *aestivalis* (Zinger) Dostál, *polycladus* (Chabert) Dostál — subsp. **bosniacus** (Behrendsen Verh. Bot. Ver. Brandenbg. **45:** 210, 1904 p. sp. sub *Alectorol.*) Soó *comb. n.* — subsp. *apterus* (Fries) Hyl. — subsp. *arenarius* U. Schneider 1962 (vielleicht nur var. der subsp. *serotinus*) — subsp. **cretaceus** (Vassilcz. Fl. SSSR. **22:** 666, 1955 p. sp.) Soó *comb. n.* — *Rh. paludosus* Schwarz 1931 ist wohl nur eine Form der proles *polycladus*.
Rh. borbasii (Dörfl.) Soó ssp. **songaricus** (Sterneck) Soó prol. **riparius** (Vassiloz. Fl. SSSR. 22: 666 p. ssp. *Rh. songarici*) Soó comb. n.
Rh. Alectorolophus Poll. 1777 ist wohl auch am besten in 2 Unterarten zu teilen, subsp. *Alectorol.* (*medius*) Rchb. (Soó) mit proles *alect.*, *arvensis* (Semler) Sch. et Th., *modestus* (Chabert) Soó, *Semleri* (Sterneck) Soó, *patulus* (Sterneck) Soó, *Kerneri* (Sterneck) Soó — und subsp. *buccalis* (Wallr.) Sch. et Th. (*subexalatus* (Schultz) Soó) proles *buccalis*, *pseudomedius* Soó, *castriferrei* Soó.

Biscutella longifolia Vill. 1779 (diploide *B. laevigata*) subsp. **budensis** (Soó Acta bot. Hung. **10:** 373, 1964 p. var. *B. laevigatae*), subsp. **hungarica** (Soó l. c. 1964 p. subsp. *B. laevigatae*) Soó *comb. n.*

Rorippa × astylis Rchb. f. *repens* (Resmerița Rev. Roum. Biol. Bot. **17:** 312, 1961 p. subsp. *R. barbareoidis*) Soó *comb. n.*

Thlaspi kovatsii Heuff. subsp. **schudichii** (Soó Bot. Közl. **37:** 180, 1940 p. var. *Th. jankae*) Soó *comb. n.* (*Th. schudichii* Soó et Kárpáti 1968 p. sp.)

Draba lasiocarpa Rochel subsp. **elongata** (Host Fl. Austr. **2:** 237, 1831 p. sp.) et subsp. **compacta** (Schott, Nym. et Ky. Analecta Bot. **50,** 1854 p. sp.) Soó *comb. n.*

Aster sedifolius L. var. **subsquamosus** (Soó Acta Bot. Hung. **12:** 366, 1966, sub *A. punctato*) Soó *comb. n.*

Anthemis tinctoria L. In Ungarn und den Nachbarländern nur subsp. *subtinctoria* (Dobroczaeva 1962) Soó 1966, Smejkal 1970

Achillea ochroleuca var. **parviflora** Soó nom. nov. (*A. Horanszkyi* Ujhelyi Ann. Hist.-Nat. Mus. Nat. Hung. **67:** 41, 1975) diese kleinblütige Form mit fein doppelt gezähnten Blättern fällt vielleicht mit *A.* × *Mihalikii* Prodan var. *pectiniformis* Kárpáti 1939 zusammen.
A. crithmifolia var. **Tuzsonii** (Ujhelyi l. c. 43, 1975 p. sp.) Soó *comb. n.* Diese robuste Form hat wohl auch nicht größeren systematischen Wert, wie andere bekannte dieser Art, soweit nicht polyploid. 2n-Zahl nicht angegeben.

Matricaria *Chamomilla* L. 1755 non 1753 (*M. inodora*) muß leider gültig **M. recutita** L. 1753 (*Chamom. r.* Rauschert 1974) heißen. *M. maritima* subsp. *inodora* (C. Koch 1843) Soó 1940, Dostál (*M. perforata* Mérat 1812 nach Rauschert 1974) darf jedoch bleiben, die beiden Taxa gehören wohl zur derselben Art, weder morphologisch, noch zytotaxonomisch keine strenge Unterschiede. *M. inodora* L. 1755 nom. illegit. als Artname. Als *Tripleurospermum*: *T. maritimum* Koch subsp. *inodorum* Hyl. ex Vaarama 1950

Leucanthemum vulgare Lam. In den letzten Jahren haben zahlreiche Autoren mit diesem schwierigen Aggregat sich befasst (so Baksay 1956—57, Böcher et Larsen 1957, Favarger 1959, 1965, Favarger et Villard 1966, Horvatić (1953, 1963), Mirković 1966, Papes 1972, 1975, Polatschek 1966, Villard 1968, Wagenitz 1977, ich selbst auch, vgl. Syn. fl. veg. Hung. **5:** 673—676, 1973, meist auf zytotaxonomischer Grundlage. Die Nomenklatur ist noch z. T. umstritten, einige Irrtümer von Baksay und Polatschek scheinen leider unausrottbar sein, sie treten noch bei Wagenitz auf. Gut sind die Bearbeitungen aber in der Flora Europaea (Heywood, IV: 175 und in der Flora d. Schweiz von Hess, Landolt und Hirzel 1973. *Chrysanthemum Leucanthemum* L. bzw. *L. vulgare* Lam. wurden von verschiedenen Autoren für mehrere Kleinarten gebraucht, eine beruhigende Typisierung ist kaum möglich, also nomen dubium resp. confusum, nur als Aggregatsname zu gebrauchen. Kurze Übersicht unserer Taxa:
1. 2n: 18 **L. praecox** Horvatić (1935 p. subsp.) 1963 (*L. vulgare* auct. plur. sic Favarger (olim), Polatschek, Soó (olim), Gutermann, Wagenitz etc.) — var. *autumnale* (St.-Amans 1821) Horvatić 1963

L. Gaudinii D. T. et Sarnth. 1882 (*L. vulgare* subsp. *alpicola* (Gremli 1898 p. sp.) Löve 1961, Alpen, Pyreneen, die Identität mit der karpatischen Sippe **L. subalpinum** (Schur 1859) Tzvelev 1961 ist noch unerklärt.
2. 2n: 36 **L. ircutianum** DC. 1837 (*L. vulgare* auct. plur., sic Soó (recentius), VILLARD etc.Huc: var. **sylvestre** (Pers. 1807 Syn. **2:** 460 p. var. *Ch. L.*) Soó comb. n. (var. *carpaticum* Rochel ex Bess. 1822) — var. **amplifolium** (Fiori et Paoletti Fl. Anal. Ital. 240, 1903 p. var. Ch. L.) Soó comb. n. (*L. vulg.* subsp. *amplifolium* Horvatić 1963, var. *praestans* Briq. et Cavill. 1916) — var. **laticeps** (Briq. et Cavill. ex Burnat Fl. Alp. Marit. **6:** 88, 1916 p. var. *Leuc. vulg.*) Soó *comb. n.*
L. leucolepis (Briq. et Cavill. 1916 p. var.) Horvatić 1963 2n: 18, 36, 54 anne var.-es variae squamis pallidis specierum plurium?
3. 2n: 54 **L. adustum** (Koch 1837) Gremli 1898 (*L. v. Ch. montanum* auct., *L. maximum* auct. nonnull.: BAKSAY, POLATSCHEK, WAGENITZ non (Ramond) DC.)
L. Margaritae (Gáyer ex Jáv. 1925) Soó 1972 (*L. adustum* ssp. *Marg.* Holub 1974, *L.* v. *Ch. maximum*, *lanceolatum* auct. hung.: BAKSAY p. p., Soó non Pers., *L. vulgare* subsp. *pannonicum* Zeleny 1972.) Ad agg. *L. atratum* (Jacq.) DC. pertinent: *L. croaticum* (Horvatić 1928 sub *Ch.*) Horvatić 1963 vel *L. atratum* subsp. *cr.* Horvatić 1963 (syn.: subsp. *platylepis* (Borb. 1877 p. sp.) Heywood 1976, späterer Unterartname), huc *L. illyricum* (Horvatić 1963 Acta Bot. Croat. 22: 210 p. var. *L. croatici*) Papes 1975 = **L. atratum** subsp. **illyricum** (Horvatić l. c.) Soó comb. n. *L. liburnicum* Horvatić (1928 sub *Ch.*) 1963 p. sp. ebenfalls eine subsp. von *L. atratum*, Horvatić 1935
4. 2n: 72 **L. heterophyllum** (Willd. 1800) DC. 1827 auch fälschlich zu *L. maximum* gezogen (noch EHREND. Liste 1973), Validität des Namens bestritten. (*L. lanceolatum* (Pers. 1807 sub *Chr.*)
5. 2n: 90 **L. maximum** (Ramond 1800) DC. 1837, alle Angaben aus Mittel- und SO-Europa (noch in Ehrend. Liste 1973) falsch, die beziehen sich auf *L. adustum* incl. *Margaritae* und *L. heterophyllum*. Bei uns nur Gartenpflanze (*Ch. L.* subsp. *maximum-hortense* Nyár. 1964)

Artemisia maritima auct. Eur. med. et orient.: **A. Santonicum** L. 1753 (vgl. die schöne Monographie von PERSSON 1974), die in zwei Unterarten zu teilen ist: subsp. *Sant.* (subsp. *monogyna* Leonova 1969, *A. monogyna* W. et K. 1801 s. str.!) 2n: 36, 54 und subsp. *patens* (Neilr. 1859) Persson 1974 (*salina* auct. Eur. med. et hung.) 2n: 18. Die echte *A. salina* Willd. 1803 ist eben *A. maritima* L. 1753 s. str., in West- und Nordeuropa.

Senecio nemorensis L. Die EHREND. Liste nennt unseren Typus (d. h. subsp. *nemorensis*) subsp. *Jacquinianus* (Rchb.) Čelak. und hält die Übergangssippe zu *S. Fuchsii*: var. *subalpestris* Br.-Bl. für subsp. *nemorensis*. Die von mir unter dem Namen subsp. *intercedens* (Beck 1892) Soó 1967 zusammengefassten

Transitus, wie *graniticus* (Beck 1892) Sch. et Thell. 1914, *silvicolus* (recte *silvicola*) Br.-Bl. 1917, *subalpestris* Br.-Bl. 1917, *lepusnicensis* Nyár. 1934, *hirsutus* (Nyár. 1950) Soó 1967 sind verschiedene lokale Transitus mit eigenem Areal oder aber Bastarde *nemorensis* × *Fuchsii*, wie *decipiens* Nyár. 1964
Jurinea mollis (Torner in L.) Rchb. 1831 Die mittelungarisch-slowakische subsp. *macrocalathia* (C. Koch 1951) Soó 1942 entspricht nach HOLUB nicht der banatischen Pflanze, darum nennt er unsere *macrocalathoides* Holub 1971; nach KOŽUHAROV (in Fl. Eur. 4. 220, 1976) gehört *macrocalathia* zur subsp. *glycacantha* (Sibth. et Sm. 1813) Hay. 1931. Diese Auffassung muss nachgeprüft werden.

Primula veris L. subsp. **inflata** (Lehm. 1817) Dom. 1951 (*canescens auct.*). O. SCHWARZ 1968 hält *inflata* für eigene Art, aber *P. veris* subsp. *canescens* und *P. inflata* gehen allmählich ineinander über, was selbst SCHWARZ anerkennt. Typische *canescens* hat an der Blattunterseite einfache, *inflata* auch verzweigte Haare. Richtig ist die Übersicht der Taxa des *Primula veris* agg. in der EHRENDORFERS Liste. Irrtümlich ist die Behauptung von SCHWARZ, dass *P. elatior* var. *villosula* Pax 1897 und *P. Benkoeiana* Borb. 1888 Synonyme von *P. elatior* subsp. *rhodopea* Schwarz 1968 sind; erstere stellt einen Transitus zu *P. leucophylla* Pax, 1897 dar, letztere gehört zu *P. intricata* Gr. et Godr.

Quercus polycarpa Schur 1851 wächst in den Gebirgen von Ödenburg und Güns, auch in Burgenland (Soó, MÁTYÁS), wohl auch weiter nach Westen, das? in EHREND. Liste ist für uns beleidigend.

Potamogeton pusillus L. in Ungarn wohl nur *P. Berchtoldii* Fieber 1833, echter *P. pusillus* (sonst nach RAUSCHERT nom. confusum): *P. panormitanus* Bivona ist noch nachzuweisen.

Ornithogalum *Gussonei* auct. hung. non Ten.: **O. Kochii** Parl. 1852 incl. subsp. *tenuifolium* (Guss. 1827) Zahariadi 1976 (Schwarz p. ssp. sub *O. Gussonei*) *O. Kochii* 2n: 14—18!, selten 36, *O. Gussonei* 2n: 28, 36.

Allium montanum F. W. Schmidt subsp. **leptophyllum** (Schur En. plant. Transs. 674 p. sp., 1866) Soó *comb. n.*, Jáv. 1925 comb. incerta. (f. *longifolium* Zapal. 1906) mit sehr schmalen und langen Blättern (o. 5—1.5 mm), Ost- und Südkarpaten von der Karpato-Ukraine (Alpen von Marmarosch) bis zur Donau, fehlt in der Fl. RPR. 11.

Scilla bifolia L. Der Linzer F. SPETA hat in den letzten Jahren (1971—1976) aufgrund zytotaxonomischer und arealgeographischer Untersuchungen eine Reihe der Kleinarten des Agg. *Scilla bifolia* unterschieden, die z. T. auch im

Gebiete des heutigen Ungarn vorkommen und von mir eher als Unterarten bewertet werden. Diese sind die folgenden: 1. *S. bifolia* s. str. (ssp. *bifolia*) kommt nach SPETA in Ungarn (und Siebenbürgen) nicht vor. 2n: 18.—2. subsp. *subtriphylla* (Schur 1866 p. sp.) Domin 1936, Soó et Jáv. 1951 p. var. (*S. Kladnii* Schur 1851 sec. SPETA) Ungarn: Alföld, Bereg-Szatmár, Békés: Doboz, wohl weiter verbreitet. Karpato-Ukraine, Siebenbürgen, bzw. Rumänien. 2n: 18— 3. subsp. *vindobonensis* Speta 1974 (1976 p. sp.) Ungarn: Kleine Schüttinsel: Szigetköz, Szentendre, Érd, Pest (Újpesti-sziget), Csepelinsel, Kéthely, Nyírség: Debrecen, Nyíregyháza, Bátorliget, Hajdúböszörmény, Kiszombor bei Makó? sonst Niederösterreich, Burgenland, Mähren, Slowakei (an der Donau) 2n: 18. — 4. subsp. *drunensis* Speta 1974 (1976 p. sp.) Österreich, Ungarn: so Transdanubien: um Simontornya, Alföld: Újszentmargita, Körösszakál; Siebenbürgen, Jugoslawien, im südlichen Tiefland. Vielleicht gehören andere Vorkommen von *Scilla bifolia* in Transdanubien (von Sopron bis Tolna) und im Mittelgebirge hierzu. SPETA hat den Text von SOÓ—JÁVORKA 1951: 856 mißverstanden, eben in Mátra und Vértes fehlt *S. b.* 2n: 36. — 5. subsp. **laxa** (Schur En. pl. Transs. 669, 1866 p. sp.) Soó *comb. n.* Nur Südsiebenbürgen, um Talmesch (Talmács), 2n: 54. Ob eine Lokalrasse? — 6. subsp. **buekkensis** (Speta Naturk. Jahrb. Linz 1976:42 p. sp.) Soó *comb. n.* Ungarn, Nördliches Mittelgebirge: Cserhát (Nagyoroszi), Karancs, Bükk: Felsőtárkány, Tarkő, Répáshuta, Sátorgebirge: Háromhuta, Mogyoróska-Boldogkőváralja. Slowakei. 2n: 54. — Die morphologischen Unterschiede sind ziemlich gering, kleinblütig sind z. B. *danubialis*, *vindobonensis*, großblütig *drunensis*, *buekkensis*, ebenso ändert sich die Farbe der Blüten, Kapseln, Samen. Sonst verweise ich auf die Originalbeschreibungen von SPETA.

Juncus geniculatus Schrank 1789 (*J. alpinus* Vill. nom. illeg.) subsp. **arthrophylla** (Brenner, p. subsp. *J. fuscoatri* Bot. Centralbl. **40:** 375, 1889) Soó *comb. n.* (Hyl. 1953 p. subsp. *J. alpini*, *J. fuscoater* Schreb.)

Dactylorhiza maculata (L.) Soó subsp. *transsilvanica* (Schur) Soó 2n: 80 FRÖHNER zog sie zur *D. Fuchsii*, die deutsche Pflanze aus dem Erzgebirge entspricht etwa unserer var. *hunyadensis* Borsos et Soó 1960, wenn sie aber zytotaxonomisch zur *D. Fuchsii* (2n: 80) gehört, dann gebührt ihr neuer Name. Auch die *hunyadensis* ist zytologisch unbekannt, vielleicht sind doch die beiden identisch.

Bolboschoenus maritimus (L.) Palla, unsere halophile Rasse ist nach tschechischen Autoren die subsp. *compactus* (Hoffm. 1804) Hejný ex Dostál 1950 (*Scirpus digynus* (Godr.) Simk.), die andere Fruchtform als subsp. *maritimus*, und 2 Griffel besitzt.

Holoschoenus romanus (L.) Fritsch subsp. *Holoschoenus* Greuter 1967: *Scirpoides H.* Soják 1973, dazu subsp. *australis* (Murr. in L. 1774) Benkert 1976.

Der Name *Holoschoenus* meiner Meinung nach soll ein nomen conservandum sein.

Carex cuprina (Sándor ex Heuff. 1862) Nendtv. ex Kern. 1863 — Sándor gab lateinische Diagnosis, Orig. die Meinung von Kerner und anderen ist ganz irrevelant. (*C. vulpina* var. *tenuior*, *C. nemorosa*, *C. Otrubae* auct. hung. et aliorum)

Festuca pallens Host hat 3 Cytotypen: 14!, 28!, 42! (*F. glauca* auct.), *F. glauca* Lam. 1788 non Vill. 1787 = *F. arvernensis* Markgr.-Dannenbg. 1977 nur in Frankreich, *F. cinerea* Vill. 1786 nur in SW-Frankreich und NW-Italien.
F. vaginata W. et K. subsp. *mucronata* (Hack.) Schwarzová 1968 = *F. vaginata* subsp. *Dominii* (Krajina) Soó 1951 in Soó—Jáv. 921 (Acta Biol. Hung. 3: 244), 1954 (Acta Bot. Hung. 2, 190 mit Basionym) = var. *amethystina* (Koch 1837) Soó 1968 incl. subvar. *mucronata* (Hack.) Soó 1965, in denselben Populationen, gemischt mit var. *vaginata*.
F. rupicola Heuff. ssp. **colorata** (Schur En. pl. Transs. 1866: 788 p. sp.) Soó comb. n. (*F. valesiaca* ssp. *colorata* Simk. 1887, *F. rupicola* ssp. *saxatilis* Rauschert 1961) — *F.* »*colorata*« ist älterer Unterartname, als »*saxatilis*«.

Poa *subcoerulea* auct. hung. et cechoslov.: **P. athroostachya** Oettingen 1925, die echte *P. subc.* ist eine halophile Seestrandpflanze, vgl. Rothm. Flora 1976. Hiezu var. **anceps** (Gaud. Fl. Helv. 1: 260, 1828 p. var. *P. pratensis*) Soó comb. n., Heget. et Heer 1840 p. sp., *P. Furcotae* Degen 1915).

Agropyrum intermedium P. B. = **A. truncatum** (Wallr. 1840 sub *Tritico*) Fuss (*Elymus t.* Melderis), subsp. **trichophorum** (Link. Linnaea 17: 325, 1843 sub *Tritico* p. sp.) Soó *comb. n.* (*Elymus trichoph.* A. et D. Löve 1975), subsp. **banaticum** (Heuff. Verh. Zool. Bot. Ges. **8:** 233, 1858 p. var. *Trit. rigidi*) Soó *comb. n.*

Phragmites communis Trin. Ich habe bisher ganz bewusst diesen altbekannten Namen gebraucht und die neuere nomenklaturische Literatur unberücksichtigt (Greuter 1967, Clayton 1968 usw.), da ich die Hoffnung hatte, dass die zwei Taxa: *Ph. communis* und *Ph. australis* doch in Artstufe unterscheidbar werden. Es ist aber heute schon zweifellos, dass das kosmopolitische Schilfrohr eine sp. coll. ist, so müssen wir diese als **Phragmites australis** (Cavan. 1799 sub *Arundine*) Trin. et Steud. 1821. em. benennen. Dazu gehören var. **salsa** (Podp. Acta Soc. Sc. Nat. Morav. II: **10**/1925) Soó *comb. n.* (*Phr. comm.* ssp. *salsa* Vicherek 1973), f. *stolonifera* (G. F. W. Meyer) Beldie 1972, f. *subuniflora* (DC.) Beldie 1972, var. *flavescens* (Custer Beldie 1972 — subsp. *humilis* De Not. 1840 bzw. subsp. **maritima** (Mabille Rech. pl. Cors. **2:** 42, 1869 p. sp.) Soó *comb. n.* (Richter 1890 p. subsp. *Ph. comm.*) — subsp. *altissima* (Benth 1826) Clayton 1968 (*Ph. comm.* subsp. *pseudodonax* (Rabenh. 1846)

Rothm. 1963 comb. inval. 2n: 72 — subsp. **maxima** (Forskål Fl. Aegypt.-Arab. 24 sub *Arundine* 1775) Soó *comb. n.* (*Ph. maxima* Chiovenda) 2n: 90

Trisetum *carpaticum* auct. non (Host) R. et Sch.: *T. fuscum* (Kit. 1814 sub *Avena* non Ard. 1789) R. et Sch. 1814 oder *T. ciliare* (Kit. 1814 sub *Avena*) Dom. 1935

Helictotrichon (incl. *Avenochloa*) in Zerteilung auf zwei Gattungen ist der ältere Gattungsname für *Avenochloa* **Avenula** Dum. **A. pratensis** Dum, wächst im Burgenland, wohl auch im ungarischen Noricum, var. *megastachya* und *subdecurrens* gehören zu *A. adsurgens. A. alpina* auct.: **A. praeusta** (Rchb. 1833 sub *Avena*) Holub 1976, bei uns die subsp. **adsurgens** (Schur 1866 nom. inval., Prod. Fl. Rom. 1: 88, 1923 sub *Avenastro*) Soó *comb. n.* (*A. adsurgens* Holub 1976), *Helictotr. microstachyum* (Borb.) Soó p. var. et subsp., *H. conjungens* (Gáyer 1932 sub *Avenastrum*) Widder 1939 usw.

Koeleria cristata (L.) Pers. nom. confusum, höchtens als Aggr.-name anzunehmen. *K. macrantha* (Ledeb. 1812 sub *Aira*) Spreng. 1824 gleich *K. cristata* subsp. *mongolica* (Dom. 1904 p. sp.) Tzvelev 1971 ist eine asiatische Pflanze, so ist der gültige Name für die mitteleuropäische »*K. cristata*« noch immer unsicher. Mehrere Taxa wurden in den neueren Florenwerken zu verschiedenen Arten sogar Gruppen gezogen. Die von Ujhelyi kürzlich (seit 1961) beschriebenen zahlreichen »Arten« wurden bisher kaum akzeptiert (vgl. Ehrend. Liste, Fl. Eur. V. ined.) Eine kritische Revision der ganzen Gattung ist nötig. Die ungarischen Taxa sind (kurz zusammengefasst) die folgenden: (vgl. Soó Syn. Fl. Veg. Hung. **5:** 388 ff.)

1. **K. glauca** (Schkuhr) DC. mit subsp. *Rochelii* (Schur) Nym.
2. **K. pyramidata** (Lam. 1791) P. B. 1912 Artgruppe bzw. Agg. Kleinarten: *K. mollis* Mann ex Opiz 1884 (z. B. Bakonyalja) 2n: 42; *K. grandis* Bess. ex Gorski 1849 (*K. Besseri* Ujhelyi 1973) so Bátorliget (*K. polonica* Dom. 1904 Polen, Sowjetunion).
3. **K. cristata** (L.) Pers. agg. em. Borb. et Domin, auch Rothmaler, Soó, Tzvelev (*K. gracilis* Pers. nom. illegit., *K. macrantha* auct. vix (Ledeb.) Spr. s. oben, so Janchen, Löve, Ehrendorfer, Humphries Fl. Eur. V. ined.) Kleinarten: *K. majoriflora* (Borb.) ex Domin 2n: 28 ? *K. pseudocristata* Domin 1903.

K. Javorkae Ujhelyi 1961 2n: 28 [dazu subsp. *Jankae* (Dom. 1904 p. var.) Soó 1971 und Nyárády, Ujhelyi 1970, kritische Sippen aus Siebenbürgen] (*K. transsilvanica* Schur 1857 et subsp. *tenuipes* (Schur 1857) Soó 1971, (Ujhelyi 1965 p. sp.) Ostkarpaten)
(*K. pseudoglauca* Schur 1857 — syn: *K. rigidula* Simk. 1887 p. p., *K. Simonkaii* Adam. 1904 p. p. — et subsp. *Fenzliana* (Schur 1859) Soó 1971 et subsp. *Csatoi* (Ujhelyi 1965) Soó 1971 — *rigidula* Simk. p. p. — Ostkarpaten]

Alle diese Taxa wurden in der Fl. Eur. zur »*K. macrantha*«, wie auch *K. Kerneri* und *K. Lamarckii* Ujhelyi 1970 zu *K. pyramidata* eingezogen.

Agrostis vinealis Salisb. 1771 (*A. canina* subsp. *montana* Hartmann, *A. coarctata* Ehrh. ex Hoffm. 1800, *stricta* J. F. Gmel. 1791, *pusilla* Dum. 1823, etc.) In O- und SO-Europa, wohl auch in Österreich und der ČSSR nur die subsp. **Syreitschikowii** (Smirnov Bull. Soc. Nat. Moscou **47:** 248, 1939 p. sp.) Soó *comb. n.*
A. stolonifera L. subsp. **stolonizans** (Bess. ex R. et Sch. Mant. 1822: 577 p. sp.) Soó *comb. n.* (*A. alba* subsp. *stolonizans* Lavrenko 1935, *A. stolonif.* subsp. *prorepens* (Koch) Rothm. 1963 nom. inval.)

Alopecurus pratensis L. var. *obscurus* Griseb, ex Ledeb. 1853 = subsp. *hybridus* (Wichura 1846 non Horn. 1813) Nym. 1889: *pseudonigricans* O. Schwarz 1949.

Nachtrag:

Weitere Neukombinationen: **Thelypteris thelypteroides** (Michx.) Holub subsp. **squamigera** (Schlechtend. Adumbr. **23,** t. 11, 1825 pro var. *Asplenii thelypteridis*) Soó *comb. n.*

Prunus Armeniaca L. convar. **Budae** (Pénzes Kert. Tanint. Közl. **5:** 16—22, 1939 p. sp.) Soó *comb. n.*

Erodium Hoefftianum C. A. May. subsp. **Neilreichii** (Janka Öst. Bot. Zschr. **17:** 101 p. sp.) Soó *comb. n.*

Campanula patula L. subsp. **Peterfii** Soó (ex. Jáv. Magy. Flóra 1926: 1080 comb. incerta, Bot. Közl. **23:** 153 p. var.) *comb. n.*

Achillea distans W. et K. subsp. **alpina** (Rochel Banatus 1828: 23 p. var. *A. magnae*) Soó comb. n. (1940 p. subsp. *A. tanacetif.*, *A. tanacetifolia* auct. carpat.)
Carduus collinus W. et K. subsp. **lobulatus** (Borb. Magy. Bot. Lap. **1:** 318, 1902 p. sp.) Soó *comb. n.* Microspecies localis, origine hybridogena?: *acanthoides* × *glaucinus* (JÁVORKA, HOLUB) (*C. spinulosus* Bert. subsp. *lob.* Soó 1974 sed *C. spinulosus* ex Fl. Eur. 4: 466 est *C. Personata* × *C. Argemone*)
Centaurea pinnatifida Schur subsp. **Sooiana** (Borhidi Ann. Hist.-Nat. Mus. Hung. 8: 219 1957 p. subsp. *C. Achtarovii* Urum.) Soó *comb. n.*
Hieracium insuetum Jord. ex Bor. subsp. **Castriferrei** (Borb. Vasm. flórája 1887: 201 p. sp.) Soó *comb. n.*
H. floribundum W. et Gr. grex **cochleatum** (N. et P. Hier. Mitteleur. 1: 700 1885 p. subsp., Zahn p. sp.) Soó comb. n.
Dianthus Carthusianorum L. subsp. **capillifrons** (Borb. Vasm. flórája 1887: 259 p. var.) Soó *comb. n.*, Jáv. 1925 comb. incerta, Neumayer p. sp.

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ARCHITECTURAL ORGANIZATION AND RELATIONSHIP OF THE HUNGARIAN GENTIANA

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The architectural variation of three species of *Gentiana* has been studied, following J. Szujkó-Lacza and Z. Szőcs (1975). Lateral branches have been noted for the first time in *G. cruciata* and *G. pneumonanthe*. Both species bear lateral branches at late flowering stage, more frequently the former and occasionally the latter. Further, while the internode length in *G. cruciata* and *G. asclepiadea* is rather normal in distribution, that of *G. pneumonanthe* shows an intermittent pattern of changes.

In all three species, the number of nodes per plant is found to be significantly and positively correlated with plant height. The frequency of intermittent changes in internode of *G. pneumonanthe* shows a significant positive correlation with plant height. In *G. cruciata*, significant correlation has been found between the log values of the mean length of the main shoots and that of the lateral branches. Further, the correlation between the mean length of the leaf sheath and the rank of the node (rank correlation) is highly significant.

The distribution of lateral branches with respect to the number of nodes shows a high diversity and low equitability values. The frequency of distribution of plant height in different height groups exhibits the highest diversity in *G. asclepiadea* and the lowest in *G. cruciata*. The highest diversity and equitability values for the frequency of flower-bearing nodes have been found in *G. pneumonanthe*.

Introduction

The term architecture was defined as "formation or construction whether as the result of conscious act or growth or of random disposition of parts" (Webster's New International Dictionary cf. Hickey 1973). Hickey (l. c.) elaborated this term and defined architecture as "an aspect of morphology which applies to the spatial configuration and coordination of those elements making up part of a plant without regard to histology, function, origin or homology". Devades and Beck used this term in this sense (1971) and did not subscribe to the view of Dormer (1945) to include in its review the functional significance of the architectural elements. Later, on the basis of their studies on *Pimpinella anisum*, J. Szujkó-Lacza—Z. Szőcs (l. c.) reinterpreted architecture as "peoportionate spatial arrangement and coordination of organs as architectural elements, modified for special functions and thereby reflecting in their proportions also environmental conditions". In the present study, we have used this term as defined by J. Szujkó-Lacza—Z. Szőcs (l. c.). The

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architecture of the plant, particularly as described by J. SZUJKÓ-LACZA—Z. SZŐCS (l. c.), has not been studied properly. GRIESEBACH (1843) measured the length of different plant parts (particularly the internodes) during the growth period and at mature stage to use the data in interpreting the intercalary growth of *Astrantia major*. Measurement of internode length was also used to describe the morphology of some species by TROLL (1937), and of *Lithospermum purpureo-coeruleum* by KOVÁTS (1973). WESSELY (1960), BARÁTH—MÁTHÉ jr.— MÁTHÉ (1973) made use of architecture to solve the taxonomic problems in *Solanum* species. Recently, J. SZUJKÓ-LACZA and Z. SZŐCS (l. c.) made an intense study of the architecture of *Pimpinella anisum* in all perspectives and stressed its significance in the characterization of species.

The architecture of the three Hungarian *Gentiana* species (excluding *G. ciliata-Gentianella*) studied here consists of the following elements: rhizome with adventitous roots, main axis of limited growth and divided into internodes of various lengths leaves of different surface areas, prominent leaf sheaths and hypogynous flowers arranged in terminal and axillary cymes.

We were tempted to carry out the present work during our field study of the three species in October 1976, when we noticed certain interesting features in them. First, we observed lateral branches, regularly in *G. cruciata* and occasionally in *G. pneumonanthe*, at a late flowering stage. This feature has not been mentioned either by any previous worker of by us during our study (J. SZUJKÓ-LACZA—S. SEN 1976). Secondly, the internode length was found to show a wide range of variation in three species. In *G. pneumonanthe*, the length of the internodes changes many times irregularly and intermittently. Another interesting feature is the presence of a well marked leaf sheath in *G. cruciata*.

The study of plant architecture is interesting as it helps to understand the mutual coordination and correlation of the different architectural elements. Diversity of different morphological characters, *viz.* distribution of internode l ength in different height groups, number of node per plant, number of flower-bearing nodes per specimen, lateral branches in *G. cruciata*, have been studied with a view to find out the probability of the frequency of appearance of these characters.

Material and methods

The present study is based on both fresh and dried materials. The dried specimens are preserved in the herbarium of the Natural History Museum, Budapest (H. B.). We collected fresh materials of *G. pneumonanthe* and *G. asclepiadea* in the village Szakonyfalu (county Vas) during October, 1976, *G. cruciata* was received by the courtesy of Mr. KOVÁTS who collected it in the Bükk Mountains (county Borsod). All materials were collected at the late flowering stage.

In the case of *G. cruciata*, the main shoot often bears opposite lateral branches, while in the other two species the lateral branches are generally absent rarely present in G. pneumonanthe. The architecture of lateral branches in G. cruciata has been studied. The length of

each internode of the lateral shoot of both the sides and the sum of the length of the internodes of each branch have been presented in Table 4. The presence of well marked leaf sheaths is another noteworthy feature of *G. cruciata*. The mean length of each sheats from base to apex has been computed on the basis of fifteen observations each.

For the study of architectural variation, the main shoot has been divided into three zones. The upper zone consists of the three uppermost internodes and the lower of the four lowermost internodes, while the middle zone comprises two internodes selected from the others, grown in the middle of shoot, by the analysis of variance. The length of each selected internode has been measured and the mean value determined. The pattern of distribution of the mean internode length in relation to the number of internodes of *G. cruciata* and *G. asclepiadea* has been illustrated. These two species have been divided into two categories each, depending on the node of development of the internode length. The distribution curve of internode length has not been drawn in the case of *G. pneumonanthe*, because the frequency of change in internode length is quite variable like as a sinus curve.

The variance of the following characters have been analysed and the results tabulated in Table 5—13 following SVÁB (1966):

a) Total number of nodes per plant in three species.
b) Length of internodes bearing lateral branches in *G. cruciata*.
c) Total length of lateral branch(es) originating from one node in *G. cruciata*.

In the case of *G. pneumonanthe*, we have calculated the frequency of change in internode length at different probability levels (Table 16).

The coefficient of correlation has been determined for the following pairs of characters, following SVÁB (1966). (The results are presented in Table 5.)

1) Total number of nodes per plant and number of nodes directly bearing flowers in each species.

In *G. cruciata:*

2) Total number of nodes per plant and number of nodes bearing flowers on lateral branches.
3) Total number of nodes bearing flowers on lateral branches and the total number of nodes bearing inflorescences flowers on the main axis.
4) Total number of inflorescence flower bearing nodes of the main axis and lateral branches, and total number of nodes without lateral shoots and inflorescence flowers.
5) Mean log values of the length of internodes bearing a lateral branch and mean log values of the length of lateral branch(es) originating from one node.
6) Mean length of the leaf sheats and the rank of their nodes (rank correlation).

In *G. pneumonanthe:*

7) Total length of the plant and the frequency of the intermittent changes in internode lengths (linear as well as log values).

Table 6. presents the results of the study of the diversity, equitability and relative equitability of the following characters:

1) Frequency of distribution of plant height in different height groups.
2) Number of nodes per plant in each species.
3) Number of flower-bearing nodes.
4) Frequency of distribution of lateral branches in G. cruciata. For the computation of diversity, we have adopted the SHANNON—WIENNER's Model (1963), for the equitability (E) we followed LLOYD and GHELARDI (1964). The relative equitability $\left(E' = \dfrac{H'}{\log \max, C''}\right)$ has been determined following J. SZUJKÓ-LACZA—SEN (1977).

Results and discussion

In the following 16 tables we demonstrate the basic details and the analysis of those data, by different methods.

According to Mitscherlich, the mean internode length in plants of limited growth follows an S-shaped distribution (cf. Went 1957). The three *Gentiana* species studied here are plants of limited growth, but their internode length

Table 1

Length of internodes of main

Serial No. of internode	1	2	3	4	5	6	7
Specimen No. 1	39	46	54	46*	52*	48	42
2	42	40	38*	38*	35*	28*	19
3	32	45	40	41	35*	45*	51*
4	30	32	44	52	53*	56*	55*
5	26	64	75	53	50	53	43
6	32	60	62*	30*	25*	20*	30
7	35	40*	50*	43*	54*	61*	53
8	15	21	22	57*	64*	65*	54*
9	21	53	54	57	45*	44*	36*
10	35	55	56	35	33	25*	23*
11	21	30	38	50	45	44	35
12	26	50	42	43	35	35	28*
13	32	45	46	40	38*	36*	30*

Table 2

Length of internodes of main shoots

Serial No. of internodes	1	2	3	4	5	6	7	8	9	10
Specimen No. 1	8	14	15	18	22	27	17	18	16	23
2a	5	7	10	9	11	26	24	21	23	12
2b	16	18	20	25	27	29	31	27	23	24
3	18	22	30	28	27	28	30	31	32	35
4	12	15	17	21	25	27	28	26	63	62
5	16	30	35	37	50	35	38	30	33	38
6	12	23	28	30	26	25	24	19	22	22
7	10	25	51	30	35	*40	*45	*65	*60□	*66□
8	6	8	10	11	12	11	13	14	14	18
9	12	25	26	28	21	23	28	31	30	25
10	13	14	20	18	21	15	16	17	25	30
11a	6	8	11	10	12	9	12	13	15	16
11b	8	11	12	13	11	12	13	15	13	11
12	7	8	6	8	11	13	21	16	15	13
13	19	20	23	19	14	16	20	22	18	28
14	9	8	10	11	17	21	23	*18	*13	
15	8	11	13	19	31	42	52	54	62	66

shoots in G. cruciata (in mm)

8	9	10	11	12	13	14	Group No.
37	28						1
14	12						1
46*	35*	25	22				1
46*	41	21	15				2
45*	54*	56*	55	49	16		1
30	25	18	12				2
30	18						1
38	21	16					1
35*	26	24	15				2
21*	18	17	15				2
40*	34*	30*	24*	31*	20	10	1
27*	26*	26*	25*	24	20	17	2
28*	26*	20*	14	11			2

* = Presence of lateral branch(es) at particular nodes.

in G. pneumonanthe (in mm)

11	12	13	14	15	16	17	18	19	20	21	22	23
26	28	43	55	45	*40□	*35□	*41□	*38□	*12□			
18	16	15	14	19	20	13	11	14	16	17	*18□	*14□
23	20	18	17	18	16	15	14	16	*14□	*13□		
30	28	27	30	28	30	32	*36□	*23□	*18□			
68	*72□	*55□	*38□	*32□	*30□							
42	55	50	41	38	32	*65	*50	*10□				
25	*30□	*38□	*37□	*32								
*57□	*30	*18										
22	36	35	39	*50□	*40□							
*22	*21	*18										
35	44	*52□	*69□	*30								
22	28	39	*16	*14								
11	12	18	19	17	21	*26	*23	*21	*17			
*11												
50	35	53	60	65	*72	*28□						
72	*74	*52	*40	*31								

* = Flower(s)-bearing node.
□ = Presence of lateral branch.
a and b indicating 1st and 2nd main shoots of the same rhizome.

Table 3

Length of internodes of mains shoots

Serial No. of internodes	1	2	3	4	5	6	7	8	9	10
Specimen No. 1a	11	14	18	40	55	50	42	40	42	41
1b	13	30	50	63	48	43	44	40	36	34
2a	6	22	50	68	62	52	50	44	35*	25*
2b	14	22	75	62	50	40	32	7	6	
2c	9	95	96	62	47	35	30*	25*	20	14
2d	35	80	87	60	55	38	32	28*	27*	24*
3a	11	12	25	36	38	46	45	43	38	35
3b	8	14	26	32	40	45	44	38	35	28
3c	11	13	21	28	35	38	42	48	41	38
4a	12	38	75	66	57	42	34	22	20*	14
4b	10	18	22	45	48	44	45	44	43	41
5a	18	46	66	67	58	48	39	41	40	39
5b	17	52	71	73	66	61	57	52	41	40
6	10	22	31	35	36	34	36	33	30	28
7	13	35	44	45	38	36	34	32	26	24
8	12	18	60	68	64	56	52	42	35	42
9a	21	60	90	68	56	42	30	20	18	8*
9b	8	12	22	84	69	38	21	18		
10	12	37	35	36	50	45	44	45	42	40
11	8	30	50	54	46	45	40	38	30	31
12	12	22	38	42	40	38	39	38	32	33
13	8	14	49	45	40	39	38*	35*	30*	28*
14	10	30	38	37	35	35	30	28	27	25*
15	7	22	52	50	45	44	38	37	28	30

does not appear to be distributed in an S-shaped pattern. Of the three species, we have studied the distribution of mean length of the internodes in relation to internode number only in *G. cruciata* and *G. asclepiadea*, because in *G. pneumonanthe* the length of the internodes changes many times irregularly and intermittently. Both *G. cruciata* and *G. asclepiadea* were divided into two categories according to pattern of change in internode length. In the first group, the internodes show a gradual increase in length from base up to middle and then a gradual decrease from middle to apex. The internodes of the other group abruptly increase from base up to middle and then decrease towards apex. The plants of the first group appear to follow a more or less normal

in G. asclepiadea (in mm)

11	12	13	14	15	16	17	18	19	20	21	Group No.
30	25	20	18*	16*	12*						1
25	22*	16	13*								1
21*	16*	8*									2
											2
											2
15											2
28	21	18	14	12	8	7	7	6*			1
21	20	18	15	12	7						1
36	28	19	12	8	6*						1
9											2
38	37	31	28	27*	22*	19*	15*	14	7*	6	1
35	30	25*	18*								1
38	35	30*	28*	23*	21*	14*					1
30*	18*	25*	16*								1
22	21	10*	19*	14*							1
40	34*	25*	24*	22*							1
											2
											1
45	39	40	42*	34*	32*	30*	29*	27*	21*		1
28	27	25*	24*	18*	17*	12*	11*	8*			1
34*	28*	24*	22*	18*	14*	11*					1
25*	22*	18*	8*								1
22*	20*	17*	13*	11*							1
27	25*	24*	22*	20*	18*	17*	14*	8*			2

* = Flower(s)-bearing node.
a, b and c indicating 1st, 2nd and 3rd main shoots of the same rhizome.

distribution in both *G. cruciata* (Fig. 1) and *G. asclepiadea*, with a slight inclination towards the right (Fig. 3). The second group also appears to follow a normal distribution except that in *G. cruciata* the curves show a slight inclination towards the left and a long tail towards the right (Fig. 2) and in the case of *G. asclepiadea* a sudden elongation up to the middle and then a slight inclination towards the right (Fig. 4). Thus the mean internode length does not appear to follow an S-shaped distribution in *G. cruciata* and *G. asclepiadea*, but rather a more or less normal distribution. A noteworthy feature of *G. cruciata* is the presence of leaf sheaths at each node. The length of the leaf sheaths gradually decrease from base to apex (Fig. 5).

The results of the variance analysis of the number of nodes per plant are presented in Tables 5—13. Though the mean number of nodes per plant is quite different in the three species, its variance does not show significant differences between the species. The number of nodes per plant can not, therefore, be a useful distinguishing character for the three *Gentiana* species.

The most interesting feature of *G. cruciata* is the development of lateral branches at a late flowering stage. This character has not been reported by any of the monographers of *Gentiana* (FRÖECH 1796, GRISEBACH 1839 and KUSNEZOW 1896—1906). The lateral branches are only rarely noticed in dried herbarium specimens, probably because most of the specimens were collected
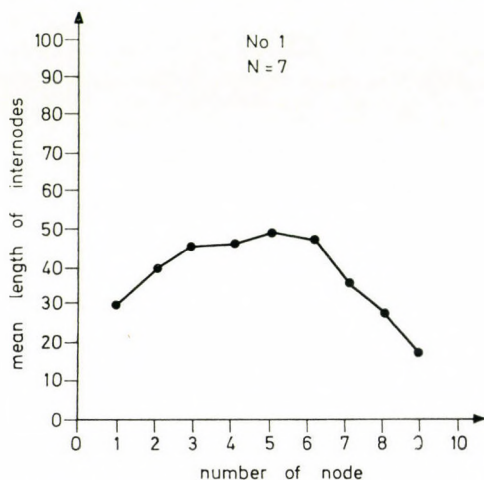
Fig. 1. No 1. *Gentiana cruciata.* Distribution of mean internode length in relation to the number of nodes (N = 7)
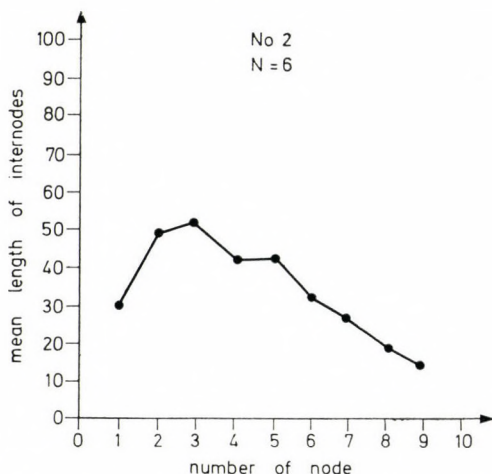
Fig. 2. No 2. *Gentiana cruciata.* Distribution of mean internode length in relation to the number of nodes (N = 6)

at early or full blooming phenophases. The lateral branches are usually opposite or alternate and develop in the acropetal succession. The lower branches are bigger, generally divided into 2—3 internodes and bear flowers, while the upper ones are shorter and occasionally bear flowers (Figs 6 and 7). The result of the variance analysis of the length of the lateral branch(es) has been found to be insignificant (Tables 5—13).

We have also made an attempt to find out the correlation coefficient of different character pairs in the three species (Table 14, 15a, b). The height of the plant and the number of the nodes show a positive correlation in all species, significant at 5% level in *G. pneumonanthe*, at 2% in *G. cruciata*, and at 0.1% in *G. asclepiadea*.
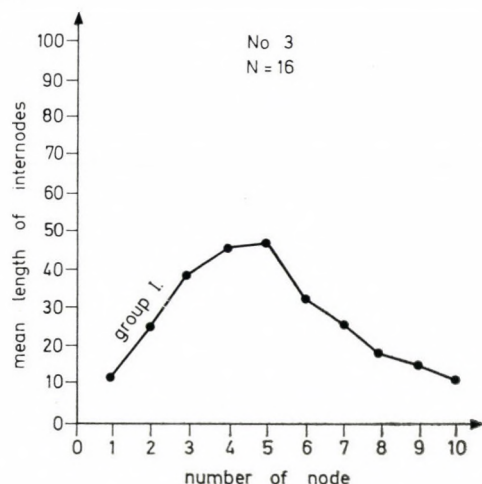
Fig. 3. No 3. *Gentiana asclepiadea.* Distribution of mean internode length relation to the number of nodes (N = 16)
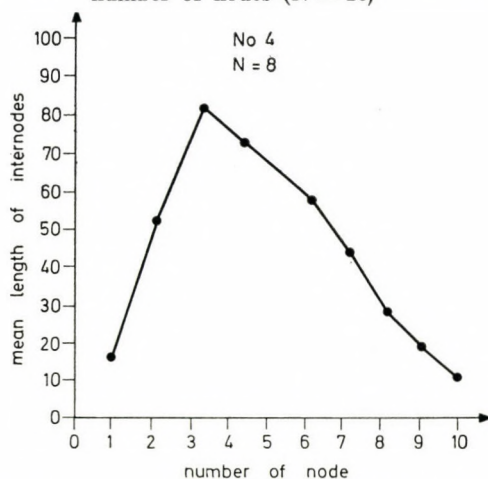
Fig. 4. No 4. *Gentiana asclepiadea.* Distribution of mean internode length in relation to the number of nodes (N = 8)
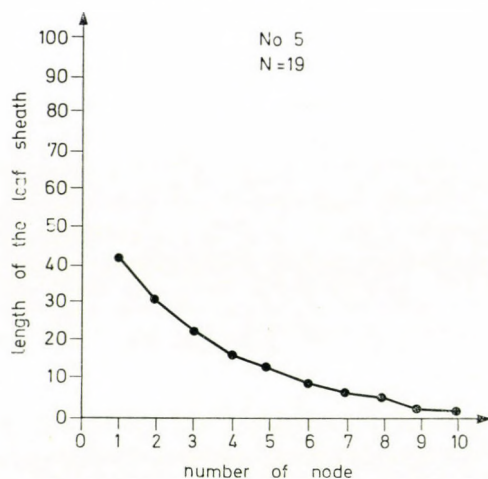
Fig. 5. No 5. *Gentiana cruciata.* Relationship between the mean length of the leaf sheath and the rank of their nodes (N = 19)

In the case of *G. cruciata*, a significant positive correlation (at 0.1%) was found between the log values of the mean length of the internode and the log values of the mean length of the branches originating from one node. The correlation between the mean length of the sheat and the rank of the node (Rank correlation) is highly significant at 0.1% level which indicates that the length of the sheats is not independent of their position.

The log values of the mean height exhibits a positive correlation (significant at 5% level) with the frequency of intermittent changes in the internode length in *G. pneumonanthe.* The intermittent changes (orthosthichous) in the internode length of *G. pneumonanthe* appears to be a characteristic feature and their frequency directly related to the plant height.

The distribution of lateral branches in relation to nodes in *G. cruciata* shows a high diversity value and low equitability (Table 16). It may, therefore, be concluded that the origin of the lateral branches is irregular.

The frequency of distribution of plant height in different height groups shows maximum diversity in *G. pneumonanthe.* The relative equitability for the same character is found to be highest in *G. asclepiadea* and lowest in *G. cruciata.* The diversity and the relative equitability values may be related to the number of shoots originating from the rhizome. In *G. asclepiadea*, 2—3 shoots arise from the rhizome while is *G. cruciata* the rhizome gives rise to numerous shoots. However, it is difficult to comment upon the values of *G. pneumonanthe* as the species is affected by frequent grazing and so the values might not be giving the true picture.

The diversity, equitability and relative equitability of the flower-bearing nodes are highest in *G. pneumonanthe.* However, the values of the other two species are also not far from those of *G. pneumonanthe.*

Table 4

Length of the lateral branches in G. cruciata

No. of specimen	Serial No. of internode	Lateral branches — Total length (in mm) — First: 1st internode	2nd	3rd	Σ	Second: 1st internode	2nd	3rd	Σ	Flower bearing node from base
1	1	61	—	—	61	57	—	—	57	4th
	2	53	—	—	53	42	—	—	42	5th
2	1	70	40	—	110	—	—	—	—	3rd
	2	34	—	—	34	38	—	—	—	4th
	3	46	16	—	62	31	—	—	31	5th
	4	22	—	—	2	20	—	—	20	6th
3	1	142	—	—	142	—	—	—	—	5th
	2	—	—	—	—	101	—	—	101	6th
	3	—	—	—	—	68	—	—	68	7th
	4	69	—	—	69	68	—	—	68	8th
	5	28	—	—	28	24	—	—	24	9th
4	1	70	40	25	135	80	55	30	165	5th
	2	78	34	—	112	91	35	—	126	6th
	3	52	—	—	52	50	—	—	50	7th
	4	15	—	—	15	14	—	—	14	8th
5	1	55	—	—	55	50	—	—	50	8th
	2	57	—	—	57	40	—	—	40	9th
	3	12	—	—	12	10	—	—	10	10th
6	1	68	10	—	78	50	27	—	77	3rd
	2	47	—	—	47	45	—	—	45	4th
	3	15	—	—	15	13	—	—	13	5th
	4	11	—	—	11	9	—	—	9	6th
7	1	—	—	—	—	130	60	—	194	2nd
	2	95	17	—	112	90	10	—	100	3rd
	3	75	—	—	75	58	—	—	58	4th
	4	50	—	—	50	45	—	—	45	5th
	5	20	—	—	20	18	—	—	18	6th
8	1	110	66	—	176	—	—	—	—	4th
	2	105	28	—	132	98	24	—	122	5th
	3	66	—	—	66	42	—	—	42	6th
	4	18	—	—	18	14	—	—	14	7th
9	1	30	—	—	30	—	—	—	—	5th
	2	—	—	—	—	28	—	—	28	6th
	3	27	—	—	27	21	—	—	21	7th
	4	18	—	—	18	10	—	—	10	8th
10	1	22	—	—	22	18	—	—	18	6th
	2	21	—	—	21	17	—	—	17	7th
	3	20	—	—	20	8	—	—	8	8th
11	1	61	—	—	61	56	—	—	56	8th
	2	46	—	—	46	42	—	—	42	9th
	3	40	—	—	40	37	—	—	37	10th
	4	25	—	—	25	19	—	—	19	11th
	5	10	—	—	10	8	—	—	8	12th
12	1	40	—	—	40	—	—	—	—	7th
	2	34	—	—	34	32	—	—	32	8th
	3	37	—	—	37	20	—	—	20	9th
	4	28	—	—	28	24	—	—	24	10th
	5	12	—	—	12	8	—	—	8	11th
13	1	50	—	—	50	36	—	—	36	5th
	2	46	—	—	46	40	—	—	40	6th
	3	32	—	—	32	30	—	—	30	7th
	4	31	—	—	31	26	—	—	26	8th
	5	13	—	—	13	10	—	—	10	9th

Fig. 6. Gentiana cruciata with lateral branches (collected in October, 1976) (Bunke Zs.)
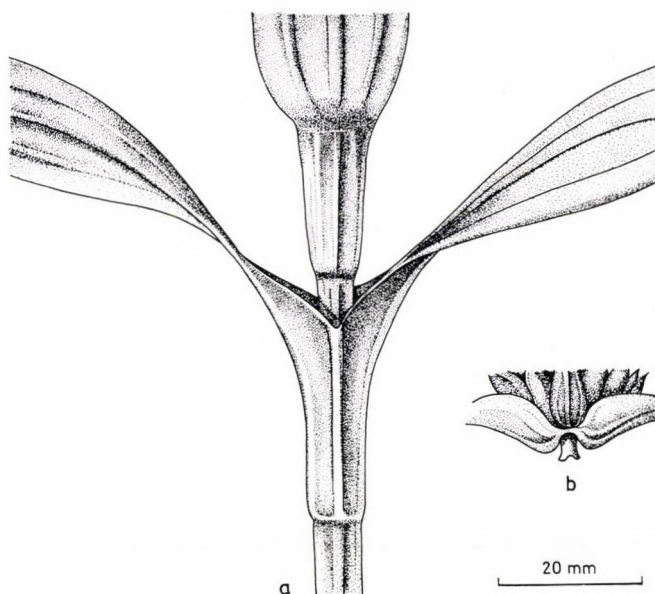
Fig. 7. Leaf sheath of *Gentiana cruciata* a, basal; *b*, apex

Table 5

Number of node/species

Specimen No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Average
Name of the species																
G. cruciata	9	9	11	11	13	10	9	10	12	11	11	14	14	12	13	11.26
G. pneumonanthe	16	14	13	9	10	11	19	15	16	11	21	14	17	14	15	15.33
G. asclepiadea	20	23	21	16	19	15	13	13	15	20	11	17	14	9	15	17.06

Table 6

Analysis of variance in the number of nodes in three species

Source of variability	SQ	FG	MQ
Treatment	177.25	44	
Residual	407.20	2	88.62
Total	584.45	42	9.69

Table 7

Average (in the diagonal), their differences (in the right upper half of the matrix) indicate no significance

Species	1	2	3
G. cruciata	11.26	4.07	5.80
G. pneumonanthe		15.33	1.73
G. asclepiadea			17.06

Table 8

Length of internodes bearing lateral branch(es) in G. cruciata

Serial number No. of specimen	1	2	3	4	Average
1	38	32	35	28	33.25
2	35	45	51	46	44.25
3	53	56	55	46	52.50
4	62	30	25	20	34.25
5	40	50	43	54	47.25
6	57	64	65	54	60.00
7	45	44	36	35	40.00
8	40	34	30	24	32.00
9	28	27	26	26	26.75
10	38	36	30	28	33.00

Table 9

Analysis of variance in the length of internodes bearing lateral branch(es)

Source of variability	SQ	FG	MQ
Treatment	3945.22	39	
Residual	1827.75	9	438.35
Total	5772.97	30	60.92

Table 10

Average (in the diagonal), their difference (in the right upper half of the matrix) indicate no significance

Specimens	1	2	3	4	5	6	7	8	9	10
1	33.25	11.00	19.25	1.00	14.00	26.75	6.75	1.25	7.25	0.25
2		44.25	8.25	10.00	3.00	15.75	4.25	12.25	18.25	11.25
3			52.50	18.25	5.25	7.50	12.50	20.50	26.50	19.50
4				34.25	13.00	25.75	5.75	2.25	8.25	1.25
5					47.25	12.75	7.25	15.25	21.25	14.25
6						60.00	20.00	28.00	34.00	29.00
7							40.00	8.00	14.00	9.00
8								32.00	6.00	1.00
9									26.00	7.00
10										33.00

Table 11

Total length of lateral branch(es) originating from one node

Serial No. of lateral branches	1	2	3	4	Average
No. of specimen					
1	110	72	93	42	79.25
2	142	101	68	137	112.00
3	300	238	102	29	167.25
4	155	92	28	20	73.75
5	194	202	133	95	156.00
6	176	255	108	32	150.75
7	30	28	48	28	40.50
8	117	88	77	44	92.50
9	40	66	57	52	66.75
10	86	86	62	57	87.00

Table 12

Variance analysis of total length of lateral branch(es) originating from one node

Source of variability	SQ	FG	MQ
Treatment	73,281.00	39	
Residual	102,299.50	9	8142.33
Total	175,580.50	30	3409.98

Table 13

Average (in the diagonal), their differences (in the right upper half of the matrix) indicate no significance

Specimen	1	2	3	4	5	6	7	8	9	10
1	79.25	32.75	88.00	5.50	76.75	70.75	38.75	13.23	12.50	7.25
2		112.00	55.25	38.25	44.00	38.00	71.50	19.50	45.25	25.00
3			167.25	93.50	11.25	17.25	126.25	74.75	100.50	80.25
4				73.75	82.25	76.25	33.25	18.75	7.00	13.25
5					156.00	6.00	115.60	63.50	89.25	69.00
6						150.00	109.50	57.50	83.25	63.00
7							40.50	52.00	26.25	46.50
8								92.50	25.75	5.50
9									66.75	20.25
10										87.00

Table 14

Frequency of the intermittent changes in the length of internodes of G. pneumonanthe

No. of changes	1	2	3	4	5	6	7	8	9
No. of specimens	0	2	3	4	4	0	3	0	1
Probability values	0	0.1176	0.1764	0.2352	0.2352	0	0.1764	0	0.0588

Table 15

A) The r values between the total number of nodes and height of the plant in three Gentiana species

G. cruciata	*G. pneumonanthe*	*G. asclepiadea*
0.5961**	0.4568*	0.7037****

Sign.: P > 5% = *; P > 2% = **; P > 1% = ***; P > 0.1% = ****.

B) The r values between the character pairs in G. cruciata

1. Total number of nodes. 2. Total number of nodes directly bearing inflorescences. 3. Total number of nodes bearing inflorescences on lateral branches. 4. Height of plant. 5. Total number of nodes bearing inflorescences on the lateral branches and total number of nodes bearing inflorescences on the main shoot. 6. Total number of nodes without lateral shoots and inflorescences. 7. Log values of the mean length of internodes bearing lateral branches. 8. Log values of the mean length of lateral branch(es) originating from one node. 9. Mean length of the leaf sheaths. 10. Rank of the nodes (from base to apex)

Character number	*G. cruciata*
1 and 2	0.1010
1 and 3	0.3447
5 and 4	0.2283
5 and 6	0.1163
7 and 8	0.9876****
9 and 10	−0.9461****

C) The r values between the total length of the plant and total number of changes in internode length in G. pneumonanthe

Normal values	Log values
0.2703	0.4157*

Table 16

1. A) Diversity values of the height of the plant, equitability and relative equitability

Name of the species	H'	E	E'
G. cruciata	1.6118	0.8283	0.3597
G. pneumonanthe	2.1500	0.9785	0.4249
G. asclepiadea	1.8050	0.7839	0.7839

B) Diversity values of the number of nodes/plant, equitability and relative equitability

Name of the species	H'	E	E'
G. cruciata	1.7488	0.9760	0.7289
G. pneumonanthe	2.1220	0.9216	0.9216
G. asclepiadea	2.2101	0.9599	0.9217

C) Diversity values of nodes-bearing flowers, equitability and relative equitability

Name of the species	H'	E	E'
G. cruciata	1.3229	0.3495	0.3635
G. pneumonanthe	1.4614	0.6213	0.7027
G. asclepiadea	0.8965	0.4311	0.4311

2. Diversity of distribution of lateral branches in G. cruciata and equitability

H'	E
1.4111	0.5884

Conclusion

We have made a comparative study of the three species at different stages of their growth, because some of the characters appear at different developmental stadia and phenophases (J. Szujkó-Lacza—G. Fekete 1973), e.g. lateral branches in *G. cruciata.* In this species, flowering starts in July and continues to the end of October (J. Szujkó-Lacza—S. Sen 1977). So at the end of the flowering season it produces lateral branches to enhance its flowering. A comparison of the curves for the mean internode length in *G. cru-*

ciata and *G. asclepiadea* and the mean length of leaf sheaths in *G. cruciata* indicates that the two organs do not show similar patterns of change from base to apex.

In the case of *G. pneumonanthe*, lateral shoots are occasionally found. Its apparent reason may be the longer flowering time. But an other possibility may, however, be that the plant grows in disturbed areas and is thus liable to frequent grasing and injury by human agencies. So it is forced to bear lateral shoots in order to continue its flowering for a longer time.

The architectural analysis has been found to be helpful to know the relationship between the architectural elements of the three species. Significant correlation values between the elements may provide a new scope for critical morphological and taxonomic studies.

In the case of diversity, we tried to find out the probability of the frequency of the appearance of the investigated characters. High diversity indicates low probability values (e.g. the distribution of lateral branches in relation to nodes is *G. cruciata*).

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EXAMINATION OF THE VERTICAL PIGMENT STRUCTURE IN AN OAK FOREST

(Quercetum petreae-cerris)*

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The vertical distribution of chlorophylls and carotenoids within plant communi ties was studied by means of pigment examinations carried out in the three main producing strata of the turkey-oak model area of the "Síkfőkút Project".** In the community, a well-expressed vertical pigment distribution was found. It is characteristic of the vertical pigment structure of the forest community that in the lower strata of the coenosis, in connexion with the downward vertical decrease of the light quantity, there occur definitely higher values of chlorophyll and carotenoid concentrations. The decrease in the chlorophyll a/b ratio of the shrub and the herb layers compared with the layer of the upper canopy may be connected with the spectral change following when light filters through a higher layer. Among the main producing strata, it is the upper canopy where most of the pigment is localized (expressed in kg/leaf area), while among the two lower layers it is the shrub layer where in summer, and the herb layer where in autumn the highest total pigment values are to be found.

Introduction

Our study comprises the photosynthetical pigment examination results obtained in the 1976 cultivation of the period summer, and autumn aspects, from the three main producing layers which structurally form the forest association in the representative research model area (Síkfőkút Project) of the Hungarian turkey-oak ecosystem. Our examinations are highly justified by the fact that in the transformation of radiation energy into potential chemical energy, on account of their role are essentially the points of departure in the energy flow of ecosystems. Therefore, in the complex ecosystem researches detailed qualitative and quantitative photosynthetical pigment investigations covering the whole plant stand of the ecosystem are indispensible.

The pigment examinations of natural plant communities mainly involve chlorophyll, and in most cases, their aim is to express the productivity rate of the community by means of the chlorophyll content (for example, H. T. ODUM—MCCONNEL—ABBOTT 1958, BRAY 1960, NEWBOULD 1967, KVĚT—ONDOK—NEČAS—JARVIS 1971). Moreover, the chlorophyll examinations of

* "Síkfőkút Project", No. 34.

** North Hungarian Middle Range, at the southern foot of the Bükk Mountain.

terrestrial plant communities mostly refer to the uni-layered herb or crop stands (for example, BROUGHAM 1958, 1960, MEDINA and LIETH 1964, OKUBO—KAWANABE—HOSHINO 1971; in Hungary, for example, ORBÁN 1972).

Complex photosynthetic pigment investigations should extend, to beside chlorophylls — pigments considered the most important —, to carotenoids as well. The importance of carotenoids is indicated by the fact that no mutant is known from which all the carotenoids would be missing and which at the same time would be able to carry out photosynthesis. Carotenoids, whose role in photosynthesis has not nearly been clarified, are absorbed to a rather significant extent by the UV, green and blue parts of the spectrum (RABINOWITCH and GOVINDJEE 1969). Their absorbed energy are delivered either through the chlorophyll-b to the effective chlorophyll-a forms (FRANCZKOWIAK—SALAMON 1970), or the energy can even directly reach the chlorophyll-a (GOEDHEER 1969), although what has been said above has as yet been proved only in the algae.

In higher order plants it is rather their part played as preventive pigments which can be stressed in that by absorbing the harmful light of shorter wave lengths, they protect, the photosynthetic apparatus from the photodestructive effect of intensive light (ANDERSON 1958 and ANDERSON—ROBERTSON 1961). According to DONOHUE (1967) and SAPOZHNIKOV (1969), xanthophylls play a significant part in the development of the photosynthetic O_2.

The synchronous examination of carotenoids, constituting an organic part of the photosynthetic pigment system, with the chlorophylls may provide such information as is not yet known, but will be of importance for a light-ecologically-centered approach to community photosynthesis.

The aim of the examinations so far was to get information on the quantitative and qualitative conditions of chlorophylls and carotenoids in the dominant species of the various layers in the forest. In addition, we concerned ourselves with the changes in the vertical pigment distribution, that is vertical pigment structure, in relation to the vertically changing light conditions in the multi-layered community.

The results of the homogeneity examinations of the homeostasis on a supraindividual level of the photosynthetic pigments of the forest community are published in another study (FEKETE—TUBA 1977).

Material and methods

The "Síkfőkút Project" model area is an about 70-year-old, homogeneous *Quercetum petraeae-cerris* community of sprout origin. The upper canopy consists of *Quercus petraeae* (84%) and *Quercus cerris* (16%). The shrub layer separates into an above-1 m upper shrub layer (*Acer campestre, Acer tataricum, Cornus mas,* etc.), and an under-1 m lower shrub layer (*Ligustrum vulgare, Euonymus verrucosus,* etc.). The dominant species of the herb layer are: *Poa nemoralis, Melica uniflora, Carex montana, Carex Michelii, Festuca heterophylla, Dactylis*

polygama, etc. The detailed characterization of the model area, and other important data are contained in JAKUCS's paper (1973).

Both species were examined in the upper canopy. The dominant shrub species studied in the summer period were: *Acer campestre*, *Acer tataricum*, *Cornus mas*, *Cornus sanguinea*, *Euonymus verrucosus*, *Ligustrum vulgare*, and the investigation covered the leaf area of all the individuals, i.e. 94% of the leaf area of the total shrub. This coverage dropped to 90% in the autumn, because the examinations in that period were extended only to *Acer campestre* and *Cornus mas*, which have higher coverage values among the two *Acer* and two *Cornus* species. The leaf area values of the three dominant herbs examined — *Carex montana*, *Melica uniflora*, *Poa nemoralis* — amount to about 80% of the total leaf area of the herb layer. In the autumn, samples were taken only from two dominant herbs, since by that time the *Poa nemoralis* was no longer suitable for pigment examinations.

The method and frequency of sampling was planned in such a way that the results shoud represent with the greatest possible occuracy the species examined, and, through the species forming the layers, the given levels. In the summer, two specimens of all the layer-forming dominant species examined and again three in the autumn, were chosen. Sample were taken from the upper, middle and lower parts of all the sample individuals, thus the various layers were represented by their entire height in the specimens. A further variation in sampling was made possible by taking samples from within the vertical small layers (for example, the middle canopy layer), at parts which are more exposed to light, or are more shaded from light. In the case of the herbaceous layers, the upper, middle and lower vertical micro levels represent those parts of the plant itself. On the basis of the viewpoints mentioned above, we gathered 60 leaves per species in the summer, and 80 in the autumn, in the morning hours, and the leaves were immediately processed. For the pigment examinations, one disc per leaf was taken with a cork screw of 0.9 cm diameter; the pigment examinations took place with 3 repetitions in summer, and again with 4 repetitions in autumn, per species, from 20 disc per repetition. The disc was taken on the basis of the leaf-half method (MARÓTI-SZAJKÓ 1972), and for that matter from the middle part of the leaf-half, since the distribution of the pigments changes in the direction from the leaf base towards the peak. The leaf ribs do not contain pigments, therefore we worked mainly with symmetrical leaves so that an identical quantity of leaf rib could get into the individual samples. From the non-discable herbaceous plants 1—1.5 cm leaf pieces, of an area about identical with that of the cork screw, were taken.

The fresh and dry weight of the discs and of the herbaceous leaf-pieces was measured. The surface of the herbaceous leaf pieces was determined by means of electronic light planimeter (CZELLÁR—PAPP, B. 1975). The extraction of pigments, and the separation of the various pigments by means of thin-layer chromatography, were carried out with the method described by MARÓTI and GABNAI (1971). The pigment quantities related to the mg/g dry weight were calculated from the extinctions measured, on the basis of the equation described by HAGER—MEYER—BERTENRATH (1966). Further calculations were made from the quantities of the individual pigment components related to 1 g dry weight.

From the interpretation of the light conditions and the pigments as complementary units (FEKETE 1972) it follows that the quantitative and qualitative conditions of the photosynthetic pigments are in close connexion with the light ecological conditions. At present we have only radiation examination results at our disposal from the model area. However, they are essentially analogous with the vertical distribution of light within the forest community. On the basis of the radiation examinations (NAGY 1976), it can be stated that during the main vegetation period, from the complete development of the foliage to its autumn disintegration, there exists a well-expressed radiation structure which can be considered as permanent. Accordingly, radiation in this period is vertically distributed in such a way that the greatest quantity is received by the canopy layer, while the shrub and the herb layers have considerable quantities of energy (Fig. 1). Indeed, identical radiation conditions are characteristic of the shrub and the herb layers, since in the forest the herb layer is rich only where no shrub layer, or hardly any of can be found; and if there exists a shrub layer, only a poor herb layer grows under that. Thus, the radiation values measured at a height of 2 m, that is in the shrub layer, can be extrapolated to the herb layer also. The examinations, both in summer and autumn, took place under the radiation conditions of the forest which had developed foliage.
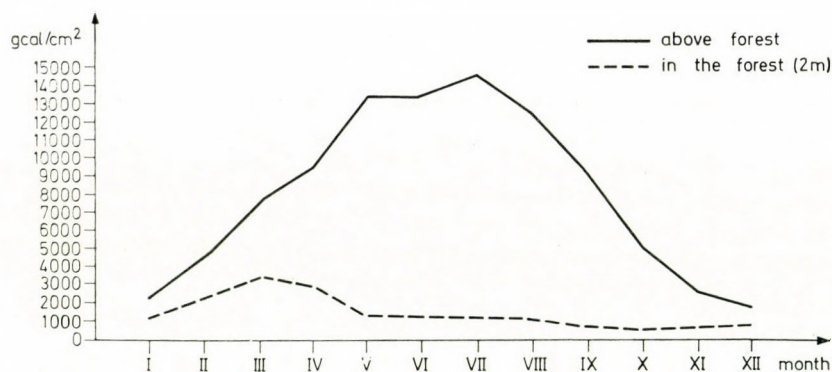
Fig. 1. Monthly values of the above-forest global radiation and of the transfused radiation measured at a height of 2 m in the forest

Results and discussion

Vertical chlorophyll distribution in the forest

The chlorophyll concentration values related to the dry weight per 1 g (Table 1), and the chlorophyll content values calculated for 1 dm^2 area show vertical distributions which are essentially different in nature.

Table 1

Chlorophyll concentration in the dominant species of the various strata of forest

Species	Chlorophyll-a, mg/g		Chlorophyll-b, mg/g		Chlorophyll a + b, mg/g	
	Summer	Autumn	Summer	Autumn	Summer	Autumn
Canopy layer:						
Quercus cerris	1.753	0.979	0.466	0.297	2.119	1.276
Quercus petraea	1.287	1.214	0.490	0.591	1.778	1.806
Shrub layer:						
Acer campestre	2.479	—	0.945	—	3.424	—
Acer tataricum	3.355	0.621	1.038	0.624	4.393	1.245
Cornus mas	3.855	0.344	0.522	0.688	4.377	1.032
Cornus sanguinea	3.101	—	1.680	—	4.781	—
Euonymus verrucosus	3.219	1.185	1.589	1.669	4.808	2.827
Ligustrum vulgare	1.887	3.171	1.085	4.313	2.979	7.484
Herb layer:						
Carex montana	1.993	3.687	0.818	2.336	2.811	6.023
Melica uniflora	3.137	5.693	1.624	3.431	4.761	9.124
Poa nemoralis	2.312	—	1.082	—	3.394	—

In summer, the following vertical distribution of the chlorophyll-a, chlorophyll-b and total chlorophyll concentrations of the various dominant species which form the layer can be stated: the lowest concentrations are to found in the canopy layer, having the greatest quantity of light, while in the shrub and herb layers, which receive only about one tenth of the light quantity falling to the canopy layer, the concentrations are essentially higher (Figs 2 and 3). The autumn results also give a distribution corresponding to that of the summer period (Figs 2 and 3). It is only the chlorophyll-a and total
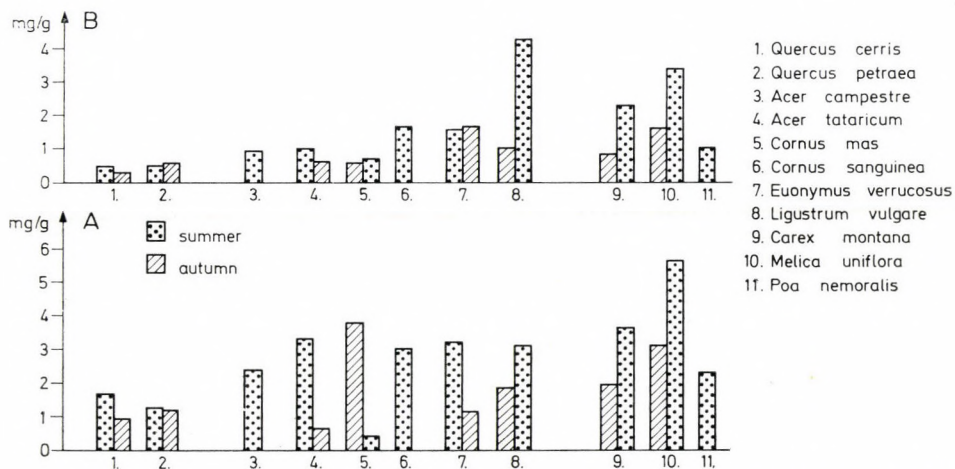
Fig. 2. Changes of chlorophyll-a(A) and chlorophyll-b(B) concentrations in the dominant species of the various strata
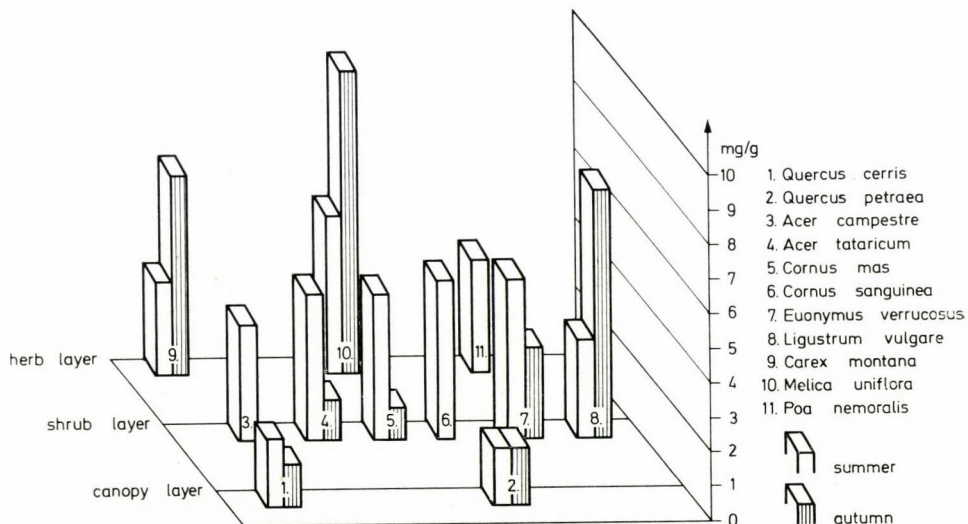
Fig. 3. Values of total chlorophyll concentration in the various strata of the Síkfőkút forest

chlorophyll contents of *Acer tataricum* and *Cornus mas* that show differences; their values are lower than those measured in the canopy of the two tree species.

The chlorophyll concentration values of *Quercus cerris* and *petraea* move within a very narrow range. In the shrub layer, more extreme values also occur, which can primarily be explained by the more extreme light conditions of this layer. Thus, in *Acer tataricum* and *Cornus mas*, the autumn chlorophyll-a and the total chlorophyll concentration is very low. The autumn chlorophyll-b and total chlorophyll concentration, which is very salient, in *Ligustrum*, is probably a manifestation of pigment reaction based on species characteristics. The rather wide interval of the absolute values of the chlorophyll concentration of the species in the herb layer is explainable by the different seasonal rhythm of these herbs.

There are very few authors who have reported a well-expressed vertical chlorophyll distribution in terrestrial communities. According to H. T. ODUM—MCCONNEL and ABBOTT (1958), it is not possible to speak of a vertical chlorophyll structure considered in general. Their examinations, however, took place mainly in water ecosystems. In a *Rizophora* community, the quantity of chlorophyll, expressed in g/m^2, was the highest in the middle layer. ICHIMURA (1956) found uppermost in a well-layered plankton community such a layer that adapted itself to a high light intensity and had only a small quantity of chlorophyll; below that, such phytoplankton layers followed which contained increas-

Table 2

Chlorophyll content values in various forest strata

Species	Chlorophyll a, mg/dm^2		Chlorophyll b, mg/dm^2		Chlorophyll a + b, mg/dm^2	
	Summer	Autumn	Summer	Autumn	Summer	Autumn
Canopy layer:						
Quercus cerris	0.913	0.518	0.242	0.157	1.155	0.675
Quercus petraea	0.723	0.718	0.280	0.353	1.003	1.071
Shrub layer:						
Acer campestre	0.801	—	0.304	—	1.105	—
Acer tataricum	0.931	0.216	0.288	0.209	1.220	0.425
Cornus mas	0.886	0.104	0.120	0.160	1.006	0.204
Cornus sanguinea	0.896	—	0.487	—	1.383	—
Euonymus verrucosus	0.756	0.252	0.374	0.367	1.130	0.619
Ligustrum vulgare	0.650	1.006	0.373	1.375	1.023	2.381
Herb layer:						
Carex montana	0.510	0.819	0.209	0.535	0.719	1.353
Melica uniflora	0.772	0.653	0.407	0.382	1.179	1.035
Poa nemoralis	0.669	—	0.314	—	0.983	—

ingly more chlorophyll. TUCKER and GARRATT (1976) measured the highest chlorophyll concentration — remarkably different from those of the lower and upper layers — in the middle, 12.5—25 cm layer of a blue grama canopy of 50 cm height. According to KUSNIRENKO (1958) the chlorophyll content is higher even in the lower layers of the canopy of trees.

The experimental results testify that there exists in multi-layered forest communities, a well-expressed chlorophyll distribution of definite tendency. However, we are able to point out the concentration increase (vertically downwards) only in relation to weights; it does not appear in relation to leaf area, since the effect of the exponentially thinning light which is anatomical in nature — on the growing of thin shade leaves — is stronger than that on the amplification of pigment concentration, which is a kind of biochemical effect. The investigations prove the same in relation to the carotenoids, too.

The chlorophyll a/b ratio, both in summer and autumn, is the highest in the canopy layer, in the two oak species; in the shrub and the herb layers — with the exception of *Cornus mas* — it is smaller than that throughout (Table 3). The changes in the a/b ratio are by all probability related to the spectral changes in light, besides the decrease in light intensity. For in a multi-layered community, the light passing the upper layers becomes filtered and undergoes spectral changes. The decrease in chlorophyll a/b ratio in the shrub and herb layers may be in connexion with such spectral changes in light, taking place during its infiltration through the canopy layer, which shirt the

Table 3

Pigment ratios in the vertical strata of forest

Species	Chlorophyll a/b ratio		Chlorophyll/carotenoid ratio	
	Summer	Autumn	Summer	Autumn
Canopy layer:				
Quercus cerris	3.763	3.297	2.022	2.140
Quercus petraea	2.625	2.054	1.311	2.144
Shrub layer:				
Acer campestre	2.623	—	1.318	—
Acer tataricum	3.233	0.996	1.643	0.874
Cornus mas	7.836	0.500	1.263	0.820
Cornus sanguinea	1.847	—	1.654	—
Euonymus verrucosus	2.026	0.694	1.708	1.182
Ligustrum vulgare	1.740	0.735	1.460	4.657
Herb layer:				
Carex montana	2.437	1.579	1.327	1.672
Melica uniflora	1.932	1.660	2.430	1.644
Poa nemoralis	2.137	—	2.426	—

spectral composition of the infiltrating light rather towards the absorption maximum of chlorophyll-b. This supposition seems to be supported by the changes identical in nature which take place in the a/b ratios of shrub and herb species existing under identical light conditions.

A remarkable difference occurs, however, also among the chlorophyll a/b ratios of the various seasons (Table 3) in a way that the autumn ratios are smaller in all the layers. Probably, in these ratio changes, the regular spectral changes of light radiation are expressed. This supposition is based also on the smaller values of autumn a/b ratios, in comparison with the summer values in *Quercus cerris* and *petraea*. In the stronger decrease in the autumn a/b ratio experienced also in the present investigations, besides the autumn light intensity again the difference between the autumn and summer spectral lights, decrease may play a part.

The vertical and seasonal distribution conditions of carotenoids

By the examinations carried out so far we wished assess the quantitative and qualitative distribution within a forest community of the carotenoids.

In the course of running a set of samples through thin-layer chromatography, the following carotenoids became separated: carotene (α and β carotene together), lutein and antheraxanthin together, violaxanthin, neoxanthin.

Table 4

Carotenoid concentration in the dominant species of various forest strata

Species	Carotene, mg/g		Lutein + Antheraxanthin, mg/g		Violaxanthin, mg/g		Neoxanthin, mg/g	
	Summer	Autumn	Summer	Autumn	Summer	Autumn	Summer	Autumn
Canopy layer:								
Quercus cerris	0.252	0.210	0.212	0.274	0.490	0.049	0.143	0.063
Quercus petraea	0.257	0.241	0.196	0.319	0.639	0.161	0.160	0.121
Shrub layer:								
Acer campestre	1.225	—	0.361	—	0.822	—	0.189	—
Acer tataricum	1.280	0.468	0.563	0.479	0.662	0.234	0.118	0.243
Cornus mas	1.335	0.325	0.576	0.560	0.990	0.228	0.564	0.145
Cornus sanguinea	0.462	—	0.738	—	1.411	—	0.279	—
Euonymus verrucosus	0.625	0.684	0.937	0.887	0.933	0.396	0.319	0.424
Ligustrum vulgare	0.416	0.224	0.500	0.563	0.879	0.550	0.240	0.270
Herb layer:								
Carex montana	1.003	0.964	0.419	1.245	0.486	0.834	0.200	0.558
Melica uniflora	1.257	1.545	0.162	2.176	0.229	0.852	0.311	0.975
Poa nemoralis	0.441	—	0.002	—	0.732	—	0.224	—

The vertical distribution of the various components (Table 4) is such that the concentration values of all the examined species in the shrub and the herb layers — with the exception of the autumn carotene of *Ligustrum vulgare* and the summer lutein and violaxanthion of *Melica uniflora* — are higher than those in tree species with foliage. The total carotene concentration shows such a definite, vertical carotenoid distribution (Fig. 4), both in summer and autumn, in which the *Quercus cerris* and *petraea* values are essentially lower
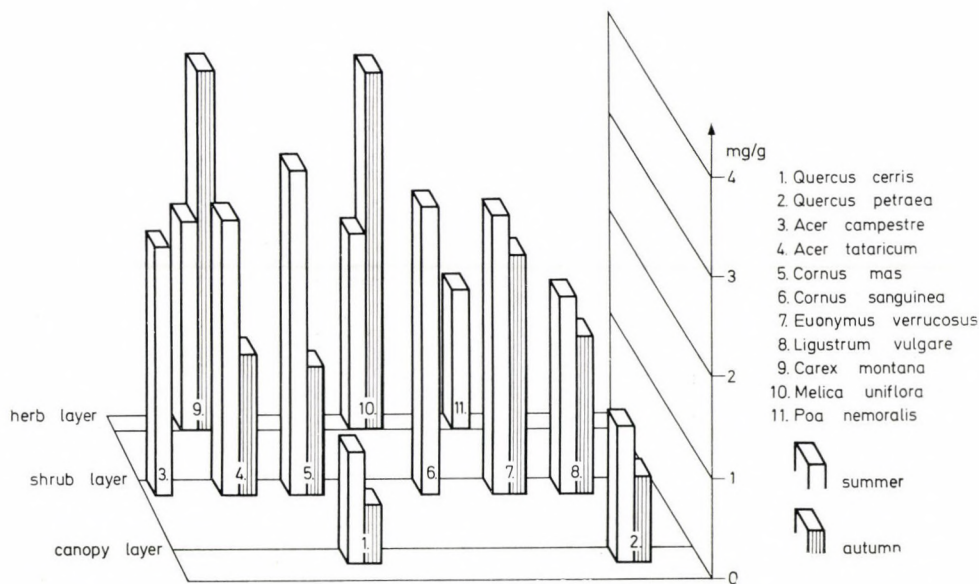
Fig. 4. Values of total carotenoid concentration

than those in all the shrub and the herb layers examined. In the carotenoid quantities calculated for dm² areas, the characteristic, vertical distribution, occuring in the concentrations, cannot be found, not even in tendency, which is due to the causes described in the section on chlorophylls.

The chlorophyll/carotenoid ratio occuring in communities is considered by E. P. Odum (1959, 1971) as a useful index of fluctuation, taking place in the life energy of the primary trophical layer. For example, in algal cultures, the ratio which is about 3 drops to 1 by aging. In natural communities, the expression of respiration losses by carotenoids is possible.

The chlorophyll/carotenoid ratios (Table 3) in summer move between 1.3 and 2.4 as regards all the three layers. In autumn, it is the highest in the canopy layers: 2.140 and 2.144. In the shrub and the herb layer smaller values than these are to be found throughout (between 0.8 and 1.7), with the exception of *Ligustrum*, where the autumn total chlorophyll, which is very high,

Table 5

Carotenoid values in the various strata of forest

Species	Carotene, mg/dm²		Lutein + Antheraxanthin, mg/dm²		Violaxanthin, mg/dm²		Neoxanthin, mg/dm²	
	Summer	Autumn	Summer	Autumn	Summer	Autumn	Summer	Autumn
Canopy layer:								
Quercus cerris	0.131	0.111	0.112	0.144	0.262	0.026	0.075	0.033
Quercus petraea	0.145	0.143	0.168	0.189	0.345	0.094	0.090	0.072
Shrub layer:								
Acer campestre	0.394	—	0.118	—	0.266	—	0.061	—
Acer tataricum	0.357	0.156	0.156	0.156	0.185	0.078	0.047	0.022
Cornus mas	0.309	0.076	0.133	0.131	0.229	0.054	0.132	0.035
Cornus sanguinea	0.132	—	0.215	—	0.432	—	0.081	—
Euonymus verrucosus	0.150	0.150	0.222	0.196	0.211	0.087	0.075	0.094
Ligustrum vulgare	0.143	0.071	0.172	0.175	0.315	0.176	0.083	0.084
Herb layer:								
Carex montana	0.257	0.230	0.109	0.297	0.127	0.203	0.051	0.136
Melica uniflora	0.314	0.172	0.037	0.244	0.066	0.096	0.077	0.109
Poa nemoralis	0.131	—	0.001	—	0.215	—	0.065	—

causes the ratio which is above 4. On the basis of all these, it seems that the decrease in the chlorophyll/carotenoid ratio indicates not only the aging of the communities but also that it decreases even within the vegetation period — towards the end of that — and also during the autumn physiological degradation, which — in the case of forest associations — begins its course first in the lower layers.

The total pigment contents of the main producing layers of the forest association

The total pigment contents of the main producing layers were calculated from the basic data. The values expressed in kg/leaf area represent the total pigment quantity contained by the total leaf area. Their calculation took place in the following way: the leaf area of the species examined is given (Jakucs—Horváth—Kárász 1975). The total leaf area in a given layer is known by means of the species constituting the layer. In the individual species, the pigment quantity to be found in the total leaf area falling to 1 ha stand area was calculated, and given in kg, from the mg/dm² pigment values, by multiplying the leaf area values falling to 1 ha by the leaf area values of the species. The value thus obtained represents pigment kg/leaf area.

In the shrub and the herb layer, where only the dominant species were examined, the pigment contents of the "remainder" leaf area, after the reduction of total leaf area of the species examined by the total leaf area of the given layer, were calculated from the pigment values related to a unit of area, expressed in dm^2 (FEKETE—TUBA 1977). In the shrub layer, the "remainder"
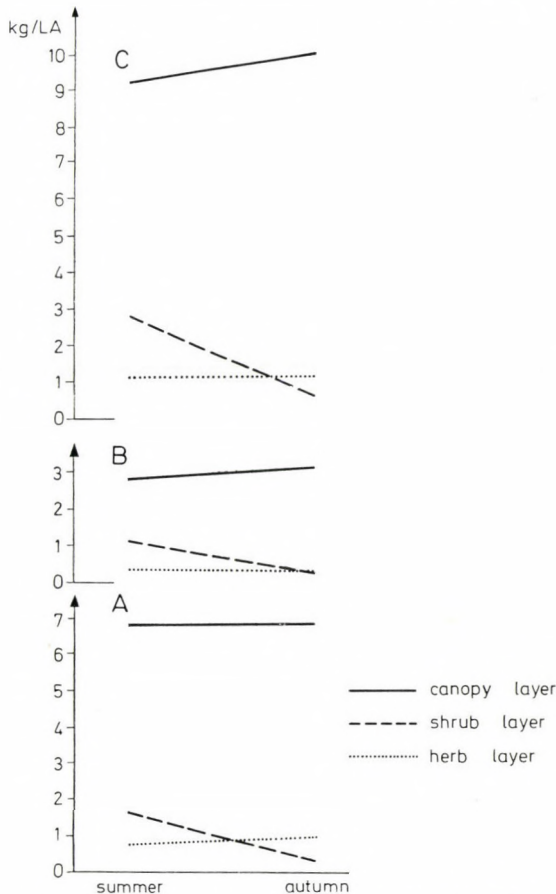
Fig. 5. Total chlorophyll content (A), total carotenoid content (B), and total pigment content (C) of the various strata of the forest of Síkfőkút

leaf area amounted to altogether 6% in summer, and 10% in autumn, of the total shrub-layer-leaf-area, and again in the herb layer to about 20%. In the canopy layer, both of the tree species were examined.

From a graphical comparison between the summer and autumn total quantities of total pigment, chlorophyll and carotenoid in the individual layers (Fig. 5), it is clear that the canopy layer has much greater quantities of pigment than the other two layers. It is only in the case of carotenoids that the difference in the quantity is smaller in this respect (Fig. 5, B). The

higher total pigment values of the shrub layer in summer drop below those of the herb layer in autumn. According to SINGH and BILLORE (1975), the pigment content of plant stands is directly proportional to the energy contents. It seems that, in the multi-layered community, the pigment contents of the various layers may also have a proportional relation with their energy contents.

Summary

On the basis of the results obtained from the pigment examinations into the *Quercetum petraeae-cerris* forest of Síkfőkút, a vertical chlorophyll and carotenoid concentration distribution with definite tendency can be stated, both in summer and autumn. It is characteristic of this, that in the canopy layer, which has the greatest quantity of light, the pigment concentration values are low, while in the shrub and herb layers, which exist in essentially weaker light conditions, definitely higher pigment concentration values can be measured in all the cases. No essential concentration differences occur between the shrub layer and the herb layer, which can be explained first of all by the nearly identical light conditions in these layers. This pigment distribution is in a close correlation with the vertical light distribution of the coenoses, which, on the other hand, depends on the number of layers in the cenosis.

Thus, it is characteristic of the vertical pigment structure of the forest association that in the lower layers of the coenosis, in connection with the downward vertical decrease in the light quantity, definitely higher chlorophyll and carotenoid concentration values occur. Owing to the strong effect on the shaded leaf production of the downward decreasing light, the above vertical pigment distribution do not appear in relation to leaf area.

The decrease in the chlorophyll a/b ratio in the shrub layer and the herb layer, in comparison with the canopy layer, may be in connected with the spectral changes which take place while the light infiltrates through the upper layer.

Considering the total pigment contents of the main producing layers, expressed in kg/leaf area, there is almost one order greater quantity of pigment localized in the canopy layer than is in the two lower layers. In summer, the values of the shrub layer are higher, in autumn those of the herb layer, in a way that in autumn the value of the shrub layer decreases below that of the autumn herb layer which is about identical at the time with the summer value.

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ON THE WOOD ANATOMY OF BOMBACOPSIS CUBENSIS A. ROBYNS (BOMBACACEAE) AND MAGNOLIA CUBENSIS URB. SSP. CUBENSIS (MAGNOLIACEAE)

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Anatomical features of the secondary xylem of these two endemic Cuban trees are described. Some morphological and ecological data are also given.

Material and Methods

Wood samples of mature trunks of both species were collected. The trunk of *Magnolia cubensis* Urb. ssp. *cubensis* was collected in the range of the Peak Marti in the Sierra Maestra, province Oriente, while the trunk of *Bombacopsis cubensis* was obtained on the road to Roncali's pharos, on the Peninsule of Guanahacabibes, province Pinar del Rio (Table 1).

Blocks of wood were aspirated under vacuum at room temperature till saturation, and softened in a J Brinzer autoclave in a solution of 50% glycerine in water.

Table 1

Wood collections and herbarium vouchers

Species and Authority	Collectors and date	Diameter of the wood sample	Place of collection	Location of herbarium vouchers
Bombacopsis cubensis A. Robyns	M. Vales and A. Borhidi, Dec. 9, 1974	10.0 cm	Peninsule of Guanahacabibes Province Pinar del Rio	Herbarium of the Academy of Sciences, Cuba
Magnolia cubensis Urb. ssp. *cubensis*	M. Vales and A. Borhidi, Jan. 10, 1976	8.5 cm	Sierra Maestra Province Oriente	Herbarium of the Academy of Sciences, Cuba

For the anatomical research, sections were obtained to a thickness of 12—15 μ, differentiated in 50% alcohol, stained in 3% Toluidin Blue, dehydrated, cleared and mounted in Canada Balsam.

Small pieces of these woods were macerated by FRANKLIN's Method (1945) in order to realize cellular studies, as for example the length of the fibers and vessel elements. One hundred measurements were made for the fibers length, while for the other features only fifty were taken.

General description

Bombacopsis cubensis A. Robyns

Little to high trees up to 25—30 m in height, with thick, generally-shaped trunks (Fig. 1). Cortex green and smooth, leaves palmate, leaflets 5—9, petiolulate, 4—8 cm long, obovate-oblong, emarginate, cuneate at base. Flowers rose or pale purple, calyx coriaceous, 3-lobed, tomentose exteriorly (Fig. 2). Stamens shorter than corolla of 5 petals; filaments purple. Capsule ovate, 5—6 cm long, brownish-yellow; seeds 6—7 mm long.

The species is endemic to West-Cuba and very common on the perpendicular slopes of the "haystack-mountains" ("mogotes"), where it is forming very interesting rocky woodlands, associated with endemic palms, e.g. *Gaussia princeps* and *Thrinax morrisii*, and with many other endemic species. These associations were studied by A. BORHIDI, who designated them as *Bombacopsi-Gaussietum* and *Bombacopsi-Thrinacetum morrisii.* A number of examples of this species can be found also on the coastal limestone dogtooth-areas of the Guanahacabibes-Peninsule, as giant emergent trees of the semideciduous *Bombacopsis-Catalpa-Diospyrus* forests.

Magnolia cubensis Urb. ssp. *cubensis*

Large trees up to 25 m in height; they are important elements of the upper canopy in the montane rain forests of the Sierra Maestra-Range, forming a *Magnolia-Laplacea-Myrsine* zone between 800 and 1700 m a. s. l. The species is endemic to Cuba and divides into 2 vicariant subspecies: ssp. *cubensis* is endemic to the Sierra Maestra-Range (Province Oriente), while ssp. *acunae* Imch. is endemic to the Escambray Mountains (Province Las Villas). Ssp. *cubensis* has a gray and smooth cortex, leaves elliptic, 6—9 cm long and 2.5—4 cm wide, base obtuse, apex shortly acuminate and obtuse, petiole 1—2 cm long. Peduncle thin, 1—2 cm long and 1—1.5 mm thick; bracts to 2 cm long. Sepals 1.3—1.6 cm, petals 1—1.3 cm long. Stamens linear, anthers 3 mm long, with a capillar appendix up to 3 mm length. Gynoeceum glabrous, consisting of 8 carpels, styles erect, or shortly recurved, 1—2 mm long.

Fig. 1. Photo of *Bombacopsis cubensis* A. Robyns. Cuba: Guanahacabibes Peninsule. (Photo A. Borhidi)

Fig. 2. Photo of the flower of *Bombacopsis cubensis* A. Robyns Cuba: Guanahacabibes Peninsule. (Photo A. Borhidi)

Wood anatomy

Bombacopsis cubensis A. Robyns

Growth-rings absent, wood diffuse porous. Pores oval, scarce, about 3 per sq. mm, predominantly solitary, rarely in groups of 2 or 3 (Fig. 3).

Length of vessel members 218.0—421.0—598.0 μ. M.F.R. 280—519 μ. Small to moderately small in size. Tangential diameter 74—116—162 μ, radial diameter 102.3—149.0—190.6 μ. Cell wall 1.8—2.7 μ thick. Intervascular pitting bordered with alternate to opposite distribution and polygonal in form. Transversal and longitudinal diameters of the borders 7.2—10.8 μ and 5.4—9.0 μ, respectively. Pit aperture smooth with a transversal diameter of 7.4—9 μ and a longitudinal diameter of 1.4—2.0 μ. Simple perforation plate (Figs 4, 7, 8).

Medullary rays. — Heterogeneous, moderately fine to medium size of 1—5 cells mostly 1—3, to 23.2—55.2—102.3 μ in width. Height, expressed in number of cells, 1—60 to 213—3550 in microns. Upright cells at the margin of medullary rays, radial size 42.6—60.7—78.1 μ, their height 50.8—74.9—110.0 μ. Procumbent cells 10.8—26.1—41.4 μ in height, 9—26.1—45.0 μ in tangential diameter, and 53.2—110.4—152.6 μ in radial size. Pitting with vessel members half bordered, of the same size (Figs 5, 6).

Fibers. — Polygonal in shape, distribution tangential, lines of 1—3 cells, or irregular. Length of the libriform fibers 1281—1866.6—2623 μ, M.F.R. 1576—2325 μ. Mean diameter 10.8—26.2—41.4 μ. Thickness of cell wall 4.5—8.1 μ. Simple pits with slit-like aperture.

Wood parenchyma. — Two different types of cells form this tissue: a ring of flattened cells around the vessels (referred by other authors as contact cells), and an apotracheal parenchyma which constitutes the ground mass of the wood, formed by roundish to irregular cells. Distributed in bands or lines of 1—2 cells between the fibers. Mean diameter 16.2—55.9—131.4 μ. Strands of 2—8 cells, height of strand parenchyma cells 88.7—128.7—159.9 μ. Cell wall 0.8—2.0 μ thick.

Magnolia cubensis Urb. ssp. *cubensis*

Wood diffuse porous, growth rings present, formed by a line of terminal parenchyma. Pores moderately numerous, roundish to oval; solitary and in short radial multiples (Fig. 9).

Vessel members very small to small, tangential diameter 35,5—74.9—99.4 μ, radial diameter 49.7—93.3—124.2 μ. Lengths of vessel members 494.5—839.5—1587 μ. M.F.R. 632.5—1081.0 μ. Cell wall 1.8—3.6 μ thick. Intervascular pitting scalariform, transversal and longitudinal diameters of borders 6.9—69 μ and 4.6—6.9 μ, respectively; transversal and longitudinal diameter of pit aperture 4.6—64.4 μ and 1.15—2.3 μ, respectively. Scalariform perforation plate with 4—15 bars (Figs 10, 13).

Fig. 3. Bombacopsis cubensis A. Robyns. Cross section 120×. Vessel within. Fungi, wood parenchyma, medullary rays and fibers

Fig. 4. Bombacopsis cubensis A. Robyns. Tangential section 120×. Vessel elements, medullary rays, fibers and strands of parenchyma

Fig. 5. Bombacopsis cubensis A. Robyns. Radial section 120×. Procumbent cells of the medullary rays

Fig. 6. Bombacopsis cubensis A. Robyns. Radial section 120×. Square and upright cells of the medullary rays

Fig. 7. Bombacopsis cubensis A. Robyns. Tangential section 300 ×. Intervascular pitting. Vessel elements with fungi. (Mark: →)
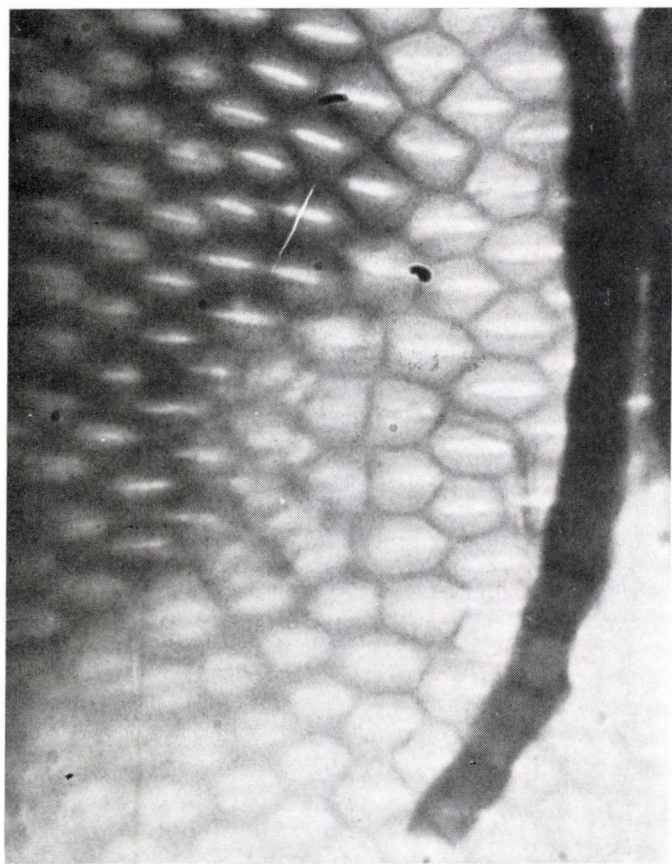
Fig. 8. Bombacopsis cubensis A. Robyns. Tangential section 600 ×. Polygonal intervascular pitting with alternate arrangement
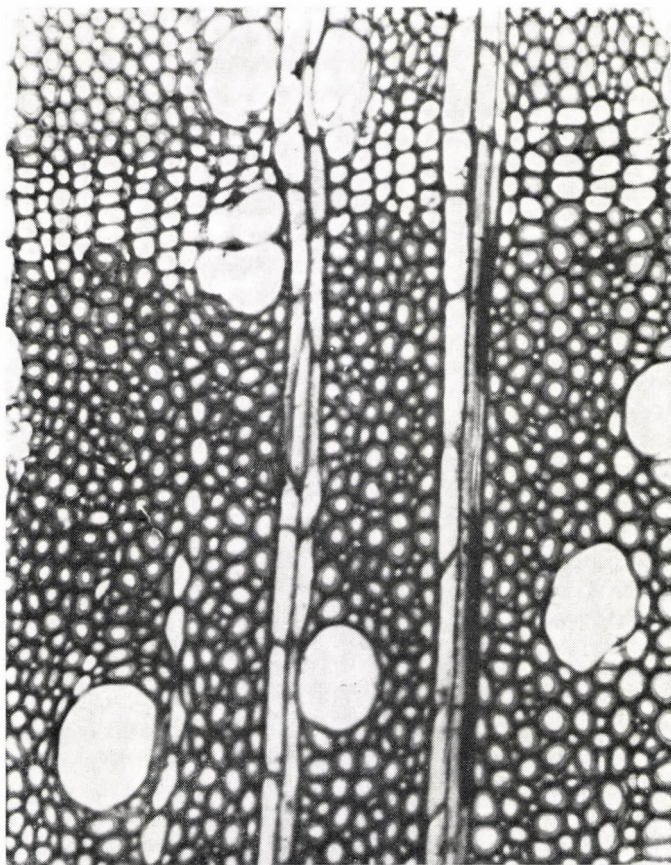
Fig. 9. Magnolia cubensis Urb. ssp. *cubensis*. Cross section. 120×. Pores oval, medullary rays, fibers with wide lumen and terminal wood parenchyma

Fig. 10. Magnolia cubensis Urb. ssp. *cubensis*. Tangential section 120×. Vessel elements, strands of parenchyma and medullary rays
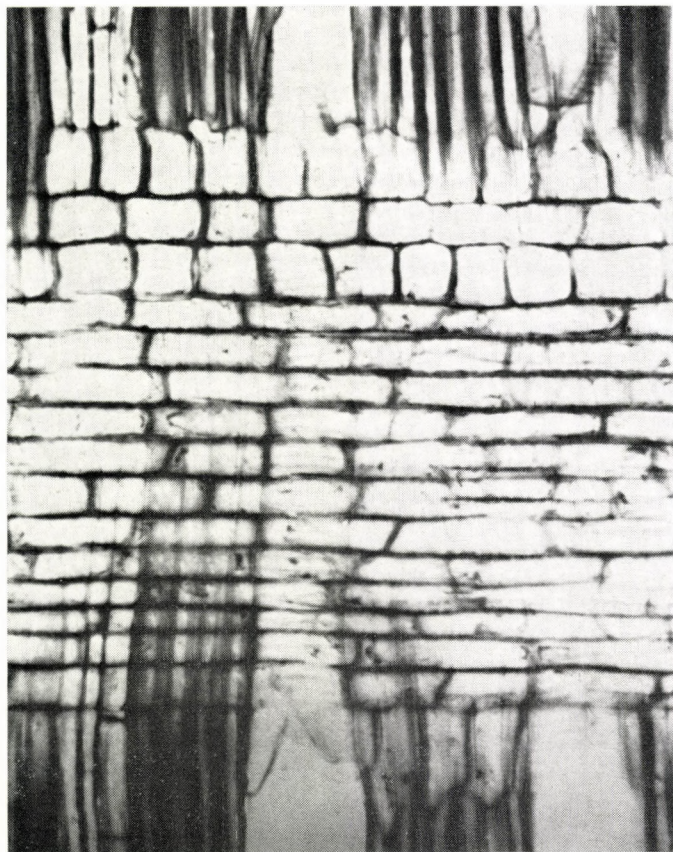
Fig. 11. Magnolia cubensis Urb. ssp. *cubensis.* Radial section 120×. Medullary rays formed of procumbent and upright cells
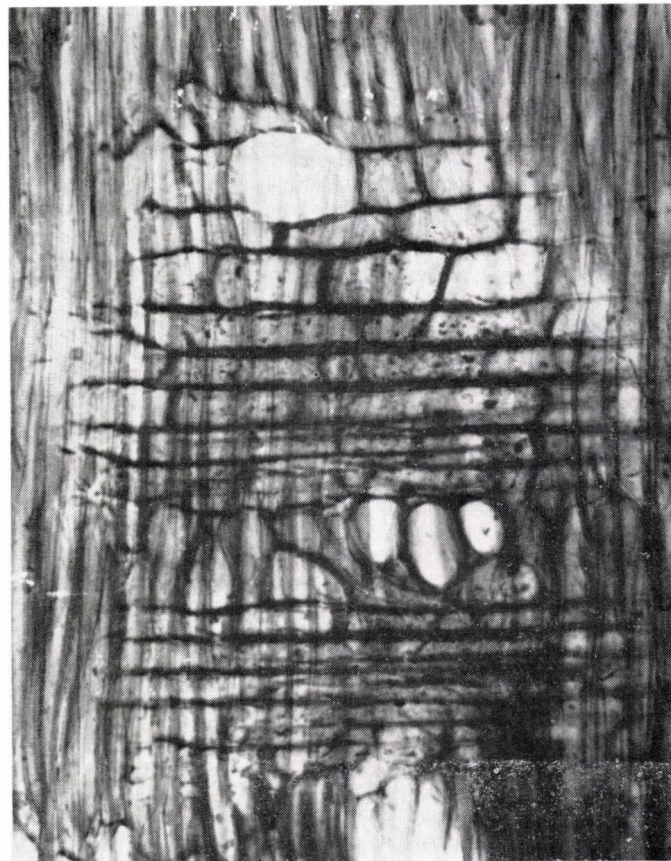
Fig. 12. Magnolia cubensis Urb. ssp. *cubensis.* Radial section 300×. Medullary ray with oil cells
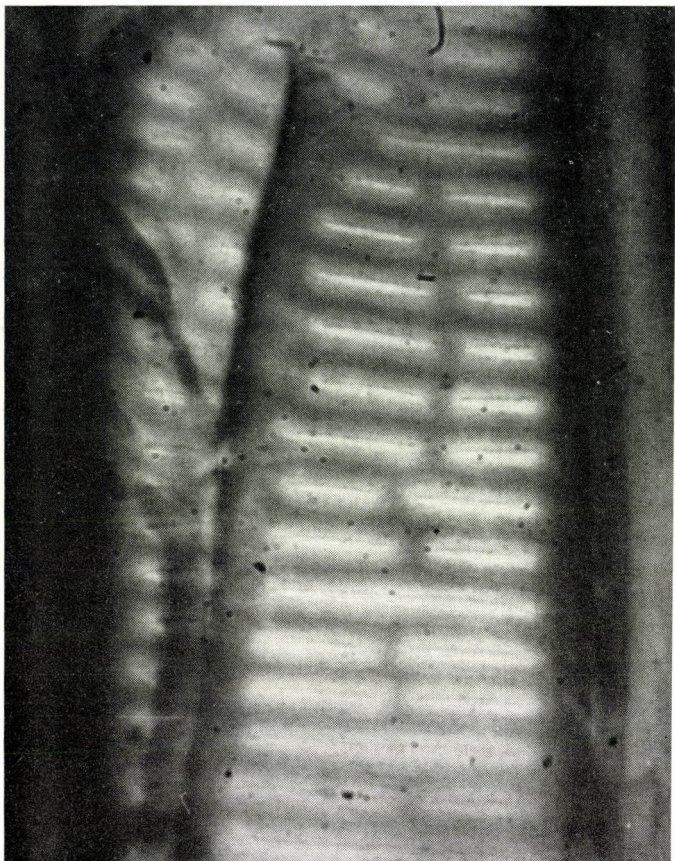
Fig. 13. Magnolia cubensis Urb. ssp. *cubensis*. 600×. Scalariform intervascular pitting to opposite

Medullary rays. — Heterogeneous, moderately fine to medium size. Uni to triseriate, 31.9—60.3 μ in width. Height by 2—24 cells, or 140.8—374.8—721.6 μ. Procumbent cells 21.3—34.7—49.7 μ in height, tangential diameter 10.6—19.8—28.4 μ, radial size 49.7—108.9—191.7 μ. Upright cells 53.2—89.8—142.0 μ in height, radial size 28.4—46.8—81.6 μ. Thickness of cell wall 1.8—3.6 μ. Oil cells very distinct in tangential and radial sections (Figs 11, 12).

Fibers. — Radial distribution irregular in form. Fiber-tracheids 976—1610.4—2196 μ in length, M.F.R. 1220—1891 μ. Mean diameter 14.4—20.7—32.4 μ. Thickness of wall 3.6—6.8—8.1 μ. Bordered pits with slit-like aperture.

Wood parenchyma. — Typically terminal, formed by a line of 2—8 rows of cells. Strand parenchyma 2—8 cells. Middle diameter 10.8—19.2—34.2 μ. Height of cells 67.4—143.4—287.5 μ. Cell wall 1.4—3.5 μ thick.

Table 2

Main features of the two species. (Values expressed in microns)

Wood element	Automatical features	*Bombacopsis cubensis* A. Robyns	*Magnolia cubensis* Urb. ssp. *cubensis*
	Arrangement	Diffuse	Diffuse
Vessel element	Tangential diameter	74.0—162.0 μ	35.5—99.4 μ
	Radial diameter	102.3—190.6 μ	49.7—124.2 μ
	Total length	218.0—598.0 μ	494.5—1578 μ
	Thickness of the wall	1.8—2.7 μ	1.8—3.6 μ
	Type of intervascular pitting	bordered, polygonal, alternate	scalariform bordered
	Perforation plate	simple	scalariform
	Classification	Heterogeneous	Heterogeneous
Medullary Rays	Width in number of cells	1—5 cells	1—3 cells
	Height	213.0—3350.0 μ	140.8—721.6 μ
	Width	23.2—102.3 μ	31.9—60.3 μ
	Other	—	Oil cells
	Arrangement	Tangential or irregular	Radial
Fibers	Diameter	10.8—41.4 μ	14.4—32.4 μ
	Total length	1281.0—2623.0 μ	976.0—2196.0 μ
	Thickness of the wall	4.5—8.1 μ	3.6—8.1 μ
	Type of pits	simple	bordered
	Arrangement	Apotracheal and contact parenchyma cells	Terminal
Wood Parenchyma	Diameter	16.2—131.4 μ	10.8—34.2 μ
	Strands formed by:	2—8 cells	2—8 cells
	Height of cells	88.7—159.7 μ	67.4—287.5 μ

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RECENSIONES

A. LÖVE and D. LÖVE: Cytotaxonomical Atlas of the Arctic Flora. Vaduz, CRAMER 1975, 598 pp.
A. LÖVE, D. LÖVE and R. E. G. PICHI SERMOLLI: Cytotaxonomical Atlas of the Pteridophyta. Vaduz, CRAMER 1977, pp. 398.

The second and the third volumes of the cytotaxonomical Atlases, launched by the LÖVES, have also been published, and even in a more satisfactory layout than was the case with the first volume. (Cf. my review in Acta Bot. Acad. Sci. Hung. 21: 452, 1975; there was given a wrong number there, it should be 1241 pp.) One of the two new volumes discusses a round 1900 taxa of the Arctic Flora, by giving their distribution, the chromosome numbers which are certain, and also the complete bibliography referring to them, and not only in respect to the specimens of Arctic origins. It is the very fact that the LÖVES know the literature perfectly well that makes their books to be of very great value, although they omit also here the numbers which do not fit into the picture created by them; on the other hand, the division of the genera and species is sometimes exaggerated. I should not be able to evaluate the different cytotypes within one agg. always as separate species. The nomenclature is absolutely up-to-date, the name *Pseudorchis*, which has been renewed by the LÖVES, is not correct, *Leucorchis* will have to stay. The reproduction of the works is much more successful and comprehensible than that in the first volume; the clumsy code numbers have been left out.

For us Hungarians, the cytotaxonomical survey of *Pteridophyta* is especially significant. PICHI SERMOLLI, who is renowned in this topic, was his collaborator in compiling the survey. The separation of *Ceterach* (and other genera), and the treatment of the cytotaxonomically different, although morphologically hardly separating microspecies as species, revives the *Ceterach javorkaeanum*. It is unfortunate that, in spite of the opinion of the Hungarian authors, *Asplenum serpentini* is not differentiated from *A. cuneifolum* (as a subspecies, at least); in my opinion, the name *Dryopteris austriaca* continues to be doubtful (cf. Soó, Acta Bot. 23: 376).

This work is especially indispensable with all the European systematists and flora researchers.

R. Soó

TÜXEN, R. et collab., Bibliographia Phyto-Sociologica. Lief. 19—30. CRAMER, Lehre resp. Vaduz, 1974—1976.

I have already reviewed in the columns of the Acta Bot. Acad. Sc. Hung. — 17: 464 and 20: 207—211 — the new great western enterprise, the phytocenological bibliography of TÜXEN, its form, aims, value and its (unfortunately, rather serious) professional shortcomings. (Especially in the case of the classes which are related to Hungary more closely, like for example *Potamogetonetea*, *Thero-Salicornietea*, *Asteretea*, *Bidentetea*, etc.) In the introduction of one of the recent issues, TÜXEN answers the various critics, but he continues to follow the way of compiling used so far, and emphasizes that the scientific assessment will be the task of another series. (This is the Prodromus of the European plant associations, of which as far as I know there has been published only one volume as yet, in 1973.) The systematization of the association groups (alliance, Verband) and of the associations mostly corresponds to that of the used by the Hungarian authors (cf. Soó, Acta Bot. Acad. Sci. Hung. 17: 27—171, Soó Synopsis syst.-geobot. Florae Veget. Hungariae 3. 1968 and 5. 1973), while there are cases when it differs from that and also from reality. In opposition to the conception of JAKUCS and of the references, TÜXEN and his collaborators continue to use the artificial *Trifolio-Geranietea* class (Lief. 24) of the forest margins, and even they enumerate the karstic shrub forests (*Orno-Cotinetalia*), and the series of *Quercetea pubescenti-petraeae* within the *Rhamno-Prunetea*, but they do not enumerate the associations of the latter among them. A similar

nonsense is the systematization of salt grass (*Juncion gerardii*, *Beckmannion eruciformis*, etc.) among the ruderal, nitrophil *Plantaginetea*. This is an old conception of TÜXEN and he is not inclined to change it, in spite of all counterarguments. It was in vain that his attention was called upon such word-monsters as *sepii*, *dumetori* (by taking the plural genitive case — *sepium*, *dumetorum* — as subjective case and conjugating it further on), it did not work, despite the fact that RAUSCHERT's excellent article (published in the very periodical of TÜXEN: Mitt. flor.-soziol. Arbeitsgem. 10: 232—249, 1963) could have taught the correct expression to the sociologists whose knowledge of the classical languages is rather poor and who nevertheless create new names.

The contents of the new instalments:

19. *Isoeto-Nanojuncetea*
20. *Nardo-Callunetea*
21. *Artemisietea vulgaris*
22. *Onopordetea acanthii*
23. *Rhamno-Prunetea*
24. *Trifolio-Geranietea*
25. *Salicetea purpureae*
26. *Alnetea glutinosae*
27. *Polygono-Poetea annuae*
28. *Plantaginetea maioris*, *Agropyretea*
29. *Asplenieta rupestria*, *Parietarietea muralis*
30. *Quercetea robori-petraeae*

R. Soó

Geobotany. Edited by R. C. ROMANS. Plenum Press, New York and London, 1976, 308 pp.

This book is the proceedings of the Geobotany Conference held at Bowling Green State University (Ohio), on February 21, 1976. It contains 16 papers of different, mainly paleobotanical, paleoecological topics. According to the intention of the editor and the purpose of the series of these conferences, all papers which are included in this volume utilized the concept of geobotany as a unifying theme. The investigators working in different fields need interactions for interpreting the problems of geology, paleoecology, paleobotany, palynology, paleoclimatology, and archeology. The value of this volume is that the diverse papers give an interdisciplinarian approach to the individual problems.

R. O. KAPP: Late Pleistocene and Postglacial plant communities of Great Lakes region.

A five-stage cycle of glacial and interglacial vegetation phases is postulated for Pleistocene and applied to data from the southern Great Lakes region. The author gives a more detailed review of the vegetation of the last half of the Pleistocene on the basis of palynological and related evidences of Late Pleistocene and Postglacial times from this region. His paleoecological suggestion is that plant communities of the Great Lakes region have had continuity throughout the late Pleistocene. There is no consistent evidence of tundra vegetation during the Late Glacial; instead, "open forests" may have existed in ice-margin areas. In possession of less evidences he also gives a sketchy but (very) remarkable reconstruction of the vegetation of Yarmouthian (Holsteinian, Mindel-Riss) and Sangamonian (Eemian, Riss-Würm) interglacial stages.

J. G. OGDEN, III.: Limiting factors in paleoenvironmental reconstruction.

Difficulties and suggestions concerning the reliable paleoenvironmental reconstruction are given in this paper.

Dealing with the validity of paleoecologic inferences the author advises the paleoecologists on the quantitative approaches to environmental reconstruction. According to his right judgement, besides the data set consisting principally of pollen, spores, diatoms or other microfossils and the enclosing sediment, the availability of large computers, capable of manipulating massive data sets, together with sophisticated statistical and library programs, provide a good opportunity for far greater detail in the reliable reconstruction of paleoenvironments.

C. W. GOOD: Taxonomic and stratigraphic significance of the dispersed spore genus Calamospora

According to the results of the present investigation a wide range of variation in spore morphology was found in the different specimens of the same cone species. The author suggests

that a clearcut division of species within the dispersed spore genus *Calamospora* is not possible. It is a great pity that this important work is not illustrated by both transmission and scanning electronmicrographs as stronger evidence.

F. W. POTTER, Jr.: Depositional and floristic interpretations of a pollen diagram from Middle Eocene, clayborne formation, Upper Mississippi embayment

Two depositional systems were operant during the examined Middle Eocene deposition, an open system (clay zone) and a closed system (lignite zone). Using the change in the depositional system, three pollen source areas, local, background, and regional, were established. Pollen present in the lignite zone generally originated from the local vegetation source areas and indicate a successional stage of the lowland vegetation surrounding the basin. Regionally derived pollen grains are very rare in the lignite but generally are represented in the clay zone.

The results show care must be taken in stratigraphic correlation and in floristic interpretation of past plant community structures and paleoclimates.

To interpret depositional environments and pollen source areas, recent pollen depositional information on small basins was used.

T. N. TAYLOR: Toward an understanding of the reproductive biology of fossil plants.

The present paper demonstrates several examples of different methods for investigating the reproductive parameters of fossil plants. The analysis of fossil plant reproductive systems provides very important information for a natural system of classification. Examined examples originated from the Pennsylvanian age and are preserved in calcium carbonate petrifactions known as coal balls. The photos, as well as the transmission and scanning electronmicrographs are very substantial proof.

H. A. MILLER: Geobotanical overview of the Bryophyta

This paper is a good summarizing work of the evolutionary development and geobotanical importance of the *Bryophyta* on the basis of the fossil records.

Present day distributions and the systematic isolation of many bryophyte groups correlate well with the history of continental land mosses and their climates.

J. L. HARR, F. T. C. TING: Modern and Paleocene Metasequoias: a comparison of foliage morphology

It is a good, well illustrated comparative examination of fossil *Metasequoia* sp. with the recent *Metasequoia glyptostroboides* Hu and Chang. The fossil *Metasequoia* sp. was well-preserved in silicified peat during the course of the Paleocene age in North Dakota.

R. A. GASTALDO: A middle Pennsylvanian nodule flora from Carterville, Illinois

A rich enumeration of 24 fossil genera and 52 species of the Herrin Coal at Carterville. Illinois, is presented. The fossil plants were found in nodules of pyritiferous clay from the middle Pennsylvanian age. The flora is dominated by the *Pecopteris* and *Neuropteris* genera. The paper is completed with very fine original photos of macrofossils.

R. L. LEARY: Paleobotanical and geological interpretations of paleoenvironments of the Eastern Interior Basin

A good paleoecological work is published here, in which the paleoenvironments determined on paleobotanical grounds are correlated with those based upon geological considerations. This includes data on the sediments enclosing the fossils, the sedimentary structures and paleotopography.

B. CORNET: Preliminary investigation of two Late Triassic Conifers from York County, Pennsylvania

This paper contains the description, comparative characterization and illustration of two fossil conifers. They originate from a rich plant-bearing layer of Late Carnian age, from the middle New Oxford Formation, in Gettysburg Basin, Pennsylvania.

J. E. CONKIN, B. M. CONKIN: North American primitive Paleozoic charophytes and descendents. This paper is a successful attempt to summarize North American primitive Paleozoic charophytes from phylogenetical, taxonomical and ecological points of view. The model and the illustrations of the evolutionary derivation of modern kinds of charophytes from the primitive forms, from the lower Devonian to the recent, are very remarkable.

D. R. Kobluk: Calcification of filaments of boring and cavity-dwelling algae and the construction of micrite envelopes

From the paper we learn the result of a very interesting experiment. Iceland spar crystal was monitored over a period of 257 days in the shallow marine environments at Discovery Bay, Jamaica. The activities of endolithic algae were observed because they are very important bioerosive and diagenetic agents in marine carbonate environments by boring actively into carbonate substrates. These activities affect particle angularity and size, sediment porosity and permeability, particle micritization, micrite envelope formation and other aspects of carbonate erosion and diagenesis.

D. M. Stothers, R. A. Yarnell: An agricultural revolution in the lower Great Lakes

Present study traces the history of the maize (*Zea mays*) agriculture from the earliest evidences of prehistoric agriculture until the recent times in the Great Lakes region. It has several radiocarbon dates.

J. F. Metress: The place of the Amerindian in the origin of the southern Appalachian grass balds

This paper is a summarizing work concerning the origin of the grass bald areas of the southern Appalachian summit. Taking into consideration the ecological and historical explanation of other scientists in the past, this issue represents a reorganization and synthesis of past and present ideas on the subject. It is supposed that the activity of Amerindians could have led to the formation of the balds as a human disclimax.

C. E. Herdendorf, D. E. Rathke, D. D. Larson, L. A. Fay: Suspended sediment and plankton relationships in Maumee river and Maumee bay of Lake Erie

This study presents the results of a complete survey to determine the quality of water issuing from the river, particularly suspended sediment, and the plankton population in the receiving body of water. The results concerning to the density of the phyto- and zooplankton populations depending on the water pollution are confirmed by a great number of diverse examinations.

S. J. Vesper, R. L. Stuckey: The return of aquatic vascular plants into the Great Lakes region after Late-Wisconsin Glaciation

By the help of radiocarbon dated records this paper traces the recolonization by aquatic vascular plants into the Great Lakes region after Late-Wisconsin glaciation. 5 genera (*Myriophyllum*, *Nymphaea*, *Potamogeton*, *Sagittaria*, *Typha*) were chosen because they are currently common and widespread in North America and most frequently recorded in pollen diagrams.

M. Járai-Komlódi

Brenan, J. P. M.—Ross, R.—Williams, J. T. (1975) Computers in botanical collections. Plenum Press, London, pp. 216.

The book is a collection of 20 papers (a few of these only abstracts) written by different authors, on using the electronic data processing (E.D.P.) methods in taxonomic plant collections in Europe and other countries.

Originally the contributors introduced this subject at a conference in the Royal Botanic Gardens Kew, from 3rd to 6th October, 1973. Almost 90 delegates, observers and speakers participated. "The purpose of this meeting is to explore areas where Electronic Data Processing can be help in the storage and retrieval of information concerned with herbarium and other preserved material" (Hawkes).

"I hope that the results will lead to an agreement on descriptors and a basic structure suitable for E.D.P. system which may be adopted by all major European botanical institution" (Rannestand). Brenan, besides having doubts with regard to E.D.P., in any major herbariums, made some suggestions for priorities based on needs at Kew. The most important and general from these are the following: the conservation of genetic resources; the label data in the herbarium are a rich source of references to economic uses of plants; to collect the vernacular names of species in different countries; the voucher specimens for non-taxonomic research, areas of special research interest; geographical survey of genera and species; to standardised family and generic catalogue etc. Brenan also established: "I must emphasize that an E.D.P.

system in the herbarium can serve a useful domestic purpose, but its usefulness is enormously increased if it becomes part of an automated inter-institutional, international information system."

The main problem as is known to all botanists, is that the type specimens, which are the "vital documents for current research" "are scattered throughout the herbaria of the world, but no central register of types or their location exists".

Further on the authors presented different methods and programmes for E.D.P. of herbarium specimen data for example for the flora of Veracruz (Gomez—Pompa et al.). Several papers deal with the herbarium specimen label information, the forms and contents of records. The more interesting examples were given by Greenes and co-workers, because they used E.D.P. for the herbarium containing specimens from the Antarctic. This herbarium differs from the other one, because of having a high percentage of unidentified material. Their data bank contain the file of identified and unidentified material for taxonomic and phytogeographical work.

The more prominent system for the taxonomist was designed by Rogers; the TAXIR (Taxonomic Information Retrieval) and by Mello, the SELGAM system.

Soper has elaborated the application of electronic data processing to the mapping of plant distribution in a book. In this volume the planning of investigation and E.D.P. are very precise and useful, unfortunately there are no interpretations of the results. A description and usefulness of the living plant record system in Botanical Gardens was discussed by Cullen.

This conference and the papers which are collected in this volume, focus attention to the needs of a data bank for the type specimens, and the possible application of different systems and the computer programmes in botanical collections.

J. Szujkó-Lacza

R. W. F. Hardy and Warren S. Silver (eds.): A treatise on dinitrogen fixation. Section III: Biology. John Wiley and Sons, New York—London—Sydney—Toronto, 1977. pp. 673.

After the publication of selected works presented at the IBP Meetings of Wageningen and Edinburgh 1970, 1974 (Biological Nitrogen Fixation in Natural and Agricultural Habitats — T. A. Lie and E. G. Mulder eds., Plant and Soil Special Volume, Martinus Nijhoff, The Hague 1971, Nitrogen fixation by free-living microorganism, Ed. by W. D. P. Stewart, IBP No. 6, University Press, Cambridge, 1975. Symbiotic Nitrogen Fixation in Plants ed. by P. S. Nutman, IBP No. 7, University Press, Cambridge, 1976) and the very good summarization of the above problem sphere: Biology of nitrogen fixation ed. by A. Quispel, North-Holland Publishing Co., Amsterdam, 1974. Nowadays a new series is under publication by A. Wiley — Interscience Publication (gen. ed. R. W. F. Hardy): Section I. Inorganic and Physical Chemistry (ed. by F. Bottomley) Section II. = Biochemistry (ed. by R. C. Burns) Section III. = Biology (ed. by W. S. Silver) Section IV. = Agronomy and Ecology (ed. by A. H. Gibson).

As regards the great importance of research on N_2-fixation we quote here a good description of the book flap on "Biology":

"There are three major reasons for intensifying the study of dinitrogen fixation: the need to increase dinitrogen fixation to facilitate the increase in crop production that will enable less developed countries to provide adequate food for their people: The increasing need to understand the earth's biological environment (the inputs and outputs from all habitats): and the need to know how perturbation of any element of existing ecosystems will influence the behavior of all component parts." Section III. "Biology" is written by 15 authors (among them American, Canadian, Indian and Scottish), also the excellent representatives of rhizobiological research in Australia F. J. Bergersen, J. S. Pate, C. A. Parker, J. M. Vincent (and E. A. Schwinghammer who works there) can be found here. In the 13 chapters the systematical list of bacteria, blue-green algae, lower plant associations (associations with fungi and green plants, lichens, *Nostoc* and a phycomycete etc.) having N_2 fixing capacity, as well as their physiology — of course with special respect to the N_2-fixation (e.g. growth requirements etc.) are elaborated.

In a very interesting chapter the foliar associations in higher plants is discussed (the leaf as a microenvironment, N_2-fixation in the phyllosphere, systematics and geographical distribution of leaf nodule plants and bacteria the potential symbionts of plants).

The latest results on N_2-fixing associations in higher plants other than legumes as well as the legume-rhizobia symbiosis are summarized too.

As regards the leguminous symbiosis it is discussed from genetical points of view (both macro- and microsymbionts and *Klebsiella*) rhizobiological aspects (*Rhizobium:* general microbiology) and a good survey is given on the infection and development of leguminous nodules, functional biology and physiological chemistry of N_2-fixation by legumes etc.

Finally a short but useful outline is presented on the "Perspectives in biological dinitrogen fixation" too. More than 2500 publications are cited in the book and though N_2-fixation as regards its biology has already been published in many thousand papers and books in the last 9 decades, but the citations of this book represent well the latest literature originating from not only a few selected journals and containing results obtained in different parts of the world. A few papers from Hungarian authors can be found too (e.g. BALASSA R., BARABÁS S., EÖRDÖGH, F., GÁBOR, M., GYŐRFFY B., KECSKÉS, M., KONDOROSI, A., OROSZ, L., SIK, T., SVÁB, S., SZENDE, K.).

The book is very useful for research workers, lecturers, students of any field of biology (mainly of course: microbiologists, botanists those working in genetics, agronomists, forestry engineers, ecologists etc.). It contains much new information for the botanists e.g. giving many good examples for the macrosymbiont-microsymbiont, microsymbiont-microsymbiont associations which are suitable for reviewing earlier points of view.

The book (and the series too) serves the better understanding of the biological basis of N_2-fixation and in this way is an important step towards solving one of the most urgent problems of our age: to produce more food and to save the traditional energy sources used in human society.

M. KECSKÉS

KINZEL, H.: Grundlagen der Stoffwechselphysiologie: Eine Einführung in die Energetik und Kinetik der Lebensvorgänge. Eugen ULMER GmbH Co; Stuttgart, 1977. 276 p., DM 22.80

The functional trends of biology, and the new results of research can only be comprehended if we have adequate fundamental knowledge of physics and physico-chemistry. Professor Dr. Helmut KINZEL, professor at the plant physiological department of the University of Vienna, wishes to provide us assistance in this. As is indicated also by the subtitle, he puts emphasis primarily on the questions of energetics and kinetics. The book consists of 15 chapters. Such questions are interdisciplinarily discussed in the various chapters that are otherwise separately dealt with in handbooks and textbooks of physics, physico-chemistry, biochemistry and physiology. Their joint discussion highly promotes a better understanding of the various biological processes.

Parallel with throwing light on the basic physical, physico-chemical notions and regularities, the book discusses the energy production of living beings, respiration and fermentation, as well as the origin of heat produced by the organism. The role of adenozintriphosphate in the energetics of organisms, as well as the utilization of ATP in carrying out work, in transport processes, and in various biosynthetical processes, are emphasized.

In the field of reaction kinetics, attention is primarily paid to catalyses and to enzymes carrying out the catalyses in the living organisms. After expounding the various notions related to this field (for example, activation energy), the author presents a comprehensive picture of the role enzymes play in metabolism, of the relationship between enzymes and substrates, of the effect of substrate-concentrations. He explains in detail the theory of MICHAELIS-MENTEN well known from enzymology, provides its mathematical analysis and LINEWEAVER-BURK-type graphical illustrations. He also interprets the physical content of MICHAELIS's constant.

When presenting the kinetical order of reactions, the author analyses the reactions of the first order. He also touches upon the reactions of the higher order. In connexion with biocatalysis, he also dwells on the kinetical conditions of reactions catalysed by enzymes.

In connexion with the various life phenomena, the book refers to the basic questions of bioregulation several times.

The author has undertaken a difficult task of elaborating the material through a modern approach, and he has succeeded in doing that, although the editing is not always consistent.

The understanding of the material of the comprehensive book is enhanced with 65 figures and 14 tables, which are partly original, while part of them are taken over from the most known text-books and handbooks. This book, which is published in the "Uni-Taschenbücher" series, will be of great value for university student who wish to absorb biology, and for young researchers and professional teachers of biology, as well as for all readers interested in biology.

MRS. B. SZAJÁNI

Wood, R. D. (1975): Hydrobotanical methods. University Park Press, Baltimore—London—Tokyo, 173 pp.

This book was written as an university manual for that reason " . . . to assist the professor in a traditional department in preparing students . . ." and " . . . to provide a series of field and laboratory projects for training university students in aquatic ecology, with emphasis on the autophyte, and to offer detailed instructions for a set of methods useful in aquatic investigation". It could be useful as a starting book for the education, and for anybody, who is interested in this topic. This book consists of 12 projects. Every project is an actual task to be solved and prepared respectively. Each project is divided into five parts as follows:

"objective" — it contains the task, what to do; "method" — it gives special and exact descriptions to carry out the investigations; "data" — it informs you on what data can be obtained after finishing the investigations; "reference" — the special literature on the subject is introduced here; "notes" — this is a substantial part of every project, procedures, devices, ideas required for the accomplishment of investigations are detailed.

The first project is about the knowledge of the examined area. This area has to be chosen with special regard to aquatic habitats. Reports can be made on the topographic features, water drainage patterns, human activity — its effect on aquatic life.

In the second project the preparation of a floristic list in the examined area is presented. This list will be a qualitative report of that area. The appropriate collection of different plant species living in water, labeling, the different ways of drying of plants, the possibilities of identifying and pressing are indicated.

The next three projects (3, 4, 5) give some information about the proper sampling methods, which are also applied in other fields. We can obtain a quantitative report of vegetation in an area. The position of each plant can be fixed along a line by using the line-transect method. The profile diagram (bisect) of a littoral vegetation in a pond, the life form association diagram, the depth-species gradient table can be prepared from the field data. By means of the quadrat method other features also can be examined, e.g. biomass, density (number of shoots per m^2), diversity (only number of species per m^2), productivity. The quadrats used generally are 1 m^2, but their sizes depend on the type and density of vegetation. Except for the former mentioned characteristics, velocity, water depth, discharge, and sediment analysis also can be made. The investigation of vegetation in deep water is carried out by indirect sampling methods. Two of them are demonstrated. One of them is the boat team transect method and the other is SCUBA team transect. The latter claims several divers with W-Z diver's sampler. It called attention to the fact that not only the benthic vegetation (fauna, too) and phytoplankton need to be studied, but their surroundings, too.

In the project 5a the author writes how a complex hydrobotanical investigation of a basin has to be carried out. The investigation needs a well equipped and well organized team. The applied procedures are discussed in alphabetic order, such as physical-chemical analysis of different elements and compounds (alkalinity, pH, nitrates, dissolved O_2 and CO_2, etc.), the descriptions of sampling instruments (Eckman dredge, Kemmerer water sampler) and the description of biological features (phytoplankton analysis, periphyton analysis, etc.).

In the project 6 we find out how a hydrographic chart of a basin has to be prepared. It is necessary for the knowledge of surface outline and depth contours. A surface outline can be drawn using any maps (topographic map, aerial photograph) or without map using plane table alidade. The recording fathometer is used to prepare depth contours, so the parameters of a lake (mean breath, mean depth, mean slope, etc.) can be calculated.

Project 7 deals with current problems, vegetation of polluted waters. The vegetation of a pollution zone is characterized by the species living there. The species are used as pollution indicators. The pollution of petrochemicals, heavy metals, BOD (biochemical oxigen demand), coliform count also have to be measured.

In project 8 some phytosociological methods are outlined, such as determination of minimum satisfactory quadrat size for study of an association; preparing an association table on the basis of abundance, constancy, cover; setting up a life form diagram. For further analysis these can be connected with measures of several environmental factors (soil, sediment, water analysis).

Project 9 is concerned with vegetation of the intertidal zone. At the study on the horizontally oriented life zones the most important moment is to establish the accurate altitude of zones investigated. To obtain the poper time of study it is necessary to know the formation of the tidal curve (it is representation of water level changes in function of time).

Project 10 outlines briefly the method of sampling used in oceanographic hydrobotany.

Project 11 deals with the diel (24-hr) changes in environmental factors of a given aquatic habitat. It concerns measures of physical-chemical factors. Schedule for sampling (that is

how many samples must be taken during 24 hours) is to be established. The more frequent the sampling the more accurate the changes of factors can be followed. The author does not deal with the diel rhythm of organisms, but it is also very important.

Project 12 acquaints us with the role of algal cultures in ecological investigations. Algal cultures can be used for testing toxicants, or for evaluating the eutrophic potential of water. The latter is based on the difference in growth of a test alga in a standard medium and in the water to be examined. The most essential techniques are also reviewed for culturing. Some recipes of media for algal culture are described.

The projects 13, 14 and 15 are about measures of primary productivity based on light and dark bottle, pigment analysis and ^{14}C uptake respectively. The methods are appropriate both for phytoplankton and for macrophytes.

The last project (16) concerns the cycling of two elements (^{32}P and ^{65}Zn) based on measuring rates of uptake of these radioisotopes. The change of ^{32}P (in water, sediment, plankton, sidewall algae, mud algae) is illustrated by an experiment carried out in an aquarium.

At the end of the book we can find a list of abbreviations commonly used in hydrobotanical literatare, as well as a glossary containing constants, terms and units. The book is complemented by author and subject indexes. The references given in the separate projects are rich enough, though they contain chiefly American references. The projects are well illustrated with figures, graphs and tables.

E. Molnár

R. G. Wiegert: Ecological Energetics. Benchmark Papers in Ecology/4. Dowden, Hutchinson, Ross, Inc., Stroudsburg, Pennsylvania, 1976, 457 pp.

This fourth volume of the book series entitled "Benchmark Papers in Ecology", edited by F. B. Golley, discusses a very important and exciting field of ecology, namely, ecological energetics. In an excellent compilation by Richard G. Wiegert, Professor at the University of Georgia, an internationally acknowledged expert on the topic, numerous valuable scientific publications are dealt with. Ecological energetics comprises studies on the transfer and conversion of energy, or materials containing energy, from one organ, population and ecosystem to another, and within these. In the past twenty years, this field of ecology has acquired a central position in intensive research. The examination of the flow of energy and of the use of energy is of fundamental importance in the research on the function of ecosystems.

R. G. Wiegert has selected 38 such articles for his book, the authors of which are also well known in the literature. With these articles, the editor presents the theoretical questions of ecological energetics, its methods of investigation and also its results in practice. Wiegert remarks that he endeavoured to choose the most important articles published in the literature, but, owing to lack of space, many of the important ones had to be left out of the compilation. It was rather the shorter, newer and more comprehensive studies that were considered in the selection. In addition to the 38 studies, 10 editor's comments provide a summary of articles on identical topics together with short supplements using other literature data not occuring in the book itself.

The book is divided into five parts. Part One: History and theory. Five articles deal mainly with the theoretical questions of ecological energetics, that is, among others, with the following topics: basic notions of production biology (A. Macfadyen), thermodynamical considerations in nutrition (R. G. Wiegert); determination of thermodynamical data and their use in ecology (D. Scott), etc. In the introductory editorial remark, the historical development of this branch of science is described.

Part Two: Energy: Levels of storage and efficiences of transfer. Eight articles deal with the determination of the caloric values of biological materials, with the caloric values of plants and animals, and with ecological efficiency. The editor placed the fundamental article published by Lindeman in 1942 in this Part.

Part Three: Energy: Rates of transfer. This Part contains sixteen articles written on topics like the primary production of communities and ecosystems; photosynthesis and respiration; secondary production; the metabolism and respiration of various animals. Several of the articles describe the methods of measuring the data obtainable with respect to the above processes. Mention is made also of the primary production of waters.

Part Four: Energetics of ecosystems. Articles on the questions of energy flow in various animal populations and communities, and of community energetics, as well as community metabolism are contained in this Part. Several of the articles are by E. H. Battley on enthalpy and free energy transformation taking place during the growth process of *Saccharomyces cerevisiae.*

Part Five: Future directions. In this short Part the editor treats the question of modelling the flow of energy, which at the same time constitutes his present topic of research. For example, the describes in short the minimum quantity of information necessary for the construction of a real non-linear discontinuous model.

I think this volume, which contains many fundamental and often not easily available articles, will be of great use and will provide great assistance to those working in the field of ecological energetics, to the university students and junior researchers who are becoming familiar with the topic, as well as to teachers. Considering its important articles the book by all means, is recommended to ecologists of soil and water as well.

B. Papp

Mathematical Analysis of Decision Problems in Ecology. Lecture notes in Biomathematics. Vol. 5. Edited by A. Charmes and W. R. Lynn.—Springer, 1975.

The volume contains the selected lectures delivered at the Conference held in Istambul, 1973. The aim of the Conference was to arrange for a meeting between the leading researchers who deal with important ecological problems in various fields of science and to present the advance of mathematical researches which may help in decision-making with regard to ecological problems.

For convenience, the book is divided into four parts: (A) Problems of Land Use Management, (B) Air, Noise and Water Pollution Control, (C) Control of Infections Disease, and (D) Social and Behavioral Analysis.

The lectures of interest for plant ecologists are to be found mainly in the part entitled Land Use Management. The paper by Bormann, H., An Ecosystem Approach to Problem Solving, summarizes the study results gained in Hubbard Brook Experimental Forest. The forest exerts a fundamental influence upon the chemical, hydrological and meteorological conditions of the area. In order to have a quantitative assessment of human influence on the region, the chemical, and hydrological cycles as well as the biological changes in the natural and the treated forests were investigated. By the effect of clear felling, the chemical and hydrological cycles became altered and considerable biological changes have taken place. The narrow-minded inappropriate interferences of agriculture, forestry and country planning, incognizant of the essential interconnections, lead to unforeseen and undesirable results. If the treatment methods in the area are based on a better understanding of the working of the ecosystem, the results can be controlled and the detrimental ones prevented.

The next lecture, entitled "A Grazing Lands Simulation Model", was delivered by Wielgolaski. The model was developed so that on the basis of the results the effects of grazing on the various types of vegetation could be compared with one another, and a more exact knowledge of the turnover in carbon and nutrient supply of the system became available. Assimilation, translocation, decayed plant parts, and decomposition were examined in the model as a function of environmental factors. Since one of the requirements of the model was that it should be available for use in a large field, its scale of resolution is relatively low, there are numerous simplifications in it. The interactions were considered linear, no consideration was given to competition between plants, to preferences of the grazing animals to certain plant species and to regeneration after grazing, etc. It seems, however, that on the basis of the model prediction is still possible with regard to the optimum size of the animal population which is still maintainable by the vegetation without a risk of damage in the cases of various environmental conditions. A further refinement of the model is possible, necessary and realizable.

The third lecture in this part (An Hierarchical Goal Programming Approach to Environmental — Land Use Management by Charmes, A., Haynes, K. E., Hazelton, J. and Ryan, M. J.) is useful for those working in environment protection (water protection).

Among the subsequent lectures there are some very interesting ones which apply the game theory to the solution of various problems. For example, Heaney, J. and Sheikh, H., "Game Theoretic Approach to Equitable Regional Environmental Quality Management", and the lecture by Bayart, D., Collomb, H., and Ponssard, J.-P., entitled "A 'Pollution' Game: A Theoretical and Experimental Study". These addresses are considered important because game theory has only to a very slight extent been applied in ecology and ecosystem researches, and so its seems an unexploited possibility.

There are among the lectures on environmental protection also some which require further research. For example, that of Loucks, D. entitled "Environmental Noise Management" and of Gotaas, H. and Galler, W., "Biological Filter Design Optimization".

The studies by Fietz, K. "Simulation Models for Genetic Control Alternatives", and Oostello, W. and Taylor, H. "Mathematical Models of the Sterile Male Technique of Insect

Control" examine the genetical and plant protection problems involving the application of sterile males.

The review of the volume discloses that ecology is interpreted by the organizers on a very wide scale and that the ecological approach is useful in many fields, and further that the researchers apply a highly divers mathematical apparatus for analysing decision problems (integro-differential equation systems, multi-level programming, stochastic processes, game theory, etc.).

No subject and author index is available in the volume which makes its use difficult. This shortcoming can be explained by the quick publication. The layout is very fine, the text is well readable, the quality of the figures is excellent.

I. Précsényi

Likens, G. E.—Borman, F. H.—Pierce, R. S.—Eaton, J. S.—Johnson, N. M., 1977: Biogeochemistry of a Forested Ecosystem. Springer, New York, Heidelberg—Berlin. 148 pp., 6 photographs, 22 tables, 31 figures

This book presents a detailed analysis of the biogeochemistry of an undisturbed northern hardwood forest ecosystem as the well-known "Hubbard Brood" ecosystem.

Approximately 50 senior scientists and a lot of graduate students have studied the Hubbard Brook ecosystem for 15 years to understand the energy and biogeochemical relationships of the forest ecosystem as completely as possible in order to propose sound land management procedures. During that time over 200 publications have come about and 2 books have appeared so far to summarize the studies at Hubbard Brook, and the third volume from this work is planned for the future.

This book is the first volume of this series. It synthesizes not only the results obtained in studying the biogeochemical flux and internal cycling of nutrients in the ecosystem, but also calls attention to the different methods applied and methodical problems, as well as emphasizing the usefulness of the "small watershed technique", which allowed measurement of input and output of chemicals and the construction of ecosystem nutrient budgets.

The ecosystem studied is a watershed or drainage area, within it there are 6 adjacent, small watersheds with similar vegetation and geology and the same climate. These sample areas provided a possibility for replication as all vegetation on 2 watersheds of the ecosystem were cut and experimentally manipulated in the late 1960-s. So a comparative study of undisturbed and perturbed ecosystems as well, could be done. The investigations began in 1963, and since then many thousands of data have been collected, which showed seasonal and year to year variations in biogeochemical flux of water and nutrients. So reliable generalizations, predictions could be made from the long-term analysis as well as from the ecosystem model.

This book consists of 8 chapters. The first one deals with the Hubbard Brook ecosystem analysis with the development of an ecosystem model. This model was applied to describe the input and output of flux and cycling of water and nutrients across the ecosystem's boundaries and within the ecosystem. It was assumed, that inputs and outputs are moved by meteorologic, geologic and biologic vectors, and the nutrients occur in 4 basic compartments, which are the following: 1. atmosphere, 2. living and dead organic matter, 3. available nutrients and 4. primary and secondary minerals. In the end the organic, available nutrient and soil and rock mineral compartments through rate processes including decomposition of organic matter, leaching and exudate from the biota, nutrient uptake by the biota, weathering of primary minerals, and formation of new secondary minerals were linked as the intrasystem cycle of the terrestrial ecosystem.

Because the ecosystem studied comprises watersheds, the second and the third chapters provide detailed information on the hydrology and the precipitation and stream water chemistry. Precipitation, streamflow, evaporation and transpiration were measured continuously and weekly samples of precipitation and stream water were collected and chemically analysed for all the ions. It is emphasized, that the meteorologic input was strongly influenced by human manipulations. It is illustrated chiefly by measuring acidity of precipitation. It was established, that S pollution and nitrate concentration have increased in the rain and snow within the last 10 years caused by industrial works and internal combustion engines. To describe changes in stream water chemistry a model has been developed, which could predict quite precisely chemical changes in the stream water and the relationships of mass nutrient output to annual streamflow within the undisturbed watershed ecosystem. But when the watershed was deforested, the model was also completely wrong. Among others this also indicates, that the regulating effects, the chemical control of ecosystems are very important.

Nutrient budgets for dissolved ions for the Hubbard Brook watersheds are elaborated in chapter four. It was determined from the difference between chemical input per hectare and geologic output (output in stream water) per hectare. Input was calculated from the product of the ionic concentration (mg/l) and the volume (liters) of water as precipitation. Output was calculated as the product of the volume (liters) of water draining from the water-ecosystem and its ionic concentration (mg/l). Budget for all of the ions and substances were measured, and annual input — output budgets, seasonal and monthly variations of it were also given.

The following chapter deals with the problems of weathering, and the total geochemical cycle of some elements are illustrated in the 6th chapter. Especially the latter shows the interaction of the hydrologic-nutrient cycle and the forest ecosystem, and strongly points at the role of controlling the ecosystem. Nutrient budget of aboveground and belowground living biomass, forest floor (litter, soil), mineral soil and rock and element fluxes in bulk precipitation, net gaseous uptake and impact of aerosols, litterfall, translocation, throughfall and stemflow, root exudation, root litter, net mineralization, uptake, hydrologic export, weathering were investigated in detail.

Finally, the original data from the Northern Hardwood Ecosystem at Hubbard Brook were compared with data from other forested ecosystems in the world and the most important results and the general conclusions were summarized.

This book is important theoretically and also from a practical point of view. It is very useful both to the scientists concerned with the theory of biogeochemical cycles and the structure and function of forested ecosystem, and to the land-use specialists, too.

The layout of this book is exemplary and the illustrations in it are excellent. All of the tables and the figures are very demonstrative.

Finally, a very valuable list of references including mainly the studies on the Hubbard Brook ecosystem can be found.

K. Virágh

Patten, B. C. (ed.) (1971, 1972): Systems analysis and simulation in ecology Vol. I.—II. Academic Press, New York 607 pp, 595 pp

Modeling, simulation and system analysis have gained more and more importance in ecology lately. They originate from physical and engineering sciences and seems to be a useful tool for solving some problems in ecology. A wide spectrum of these problems and approaches to solve them can be found in the four volumes (Vol. III. and IV. will be reviewed in the next issue).

Each volume contains a list of the contributors (with their addresses), a general index and the contents of the preceding volumes. The separate volumes are built up of a few parts, each containing several chapters and a short summary of them. Each chapter is an original work written by several authors and has its own reference list. The works are of different size and well-illustrated by tables, graphs, maps, computer program details, etc. The topics of the separate chapters vary in wide range from introduction to modeling to applications and prospects, and/or new theories. The models described are at different stages of development, both in theory and in operations. That is easy to understand, as the approaches to develop a model, the aims of a model, the degree of abstraction, the field-work, etc., depend on the nature of the starting problem, so solution ranges over a large scale. Therefore a uniform treatment of the subject "ecosystem modeling" is impossibile and meaningless. In the four volumes we can find numerous ways of abstraction, model building, etc. As the volumes are not comprehensive wholes, the chapters are separate works having parts in common chiefly in their introductions and theoretical fundamentals. So reviewing would entail repetition and overlapping, and would require a lot of space. Therefore the reviews of the separate chapters vary in size and detail.

Volume I.

It consists of three parts.

Part I.

This section gives a short introduction to modeling in two chapters.

The first chapter gives a brief and elementary interpretation of a system, the state of a system, and some types of population and ecosystem models (e.g. population competition,

feedback, block diagram, compartment models, etc.). It also treats the elements of analog and digital computation, and comparison of them. This is connected with an introduction to the program languages Fortran IV and s/360 CSMP. The text is well illustrated with examples.

Chapter 2 presents a rationale for ecological model-building used as an example a pine-moore food web. We can know the steps of model building discussed in detail, the difference between non-dynamic and dynamic state variables, the main outlines of linear and non-linear system analysis.

Part II.

It treats one-species models in three chapters.

Chapter 3 deals with the mathematical analysis of a microbial population, both in continuous and batch cultures.

Chapter 4 presents the study of the bioenergetics of *Armadillidium*, a terrestrial isopod. It applies concepts from control theory, and the transfer function technique of classical dynamic analysis.

Chapter 5 is about a study on the energetics of the fish *Micropterus salmoides* based on laboratory experiments. A computer model of various ways by which the predator dissipates energy was developed. The idea of analysing the filmed feeding sessions is very interesting. This is a new possibility, which can be used to connect ethological studies with computer analysis.

Part III.

This section contains five chapters. They show various aspects and philosophies of simulation of different ecosystems.

Chapter 6 gives a general population model at single-species level. According to the author's opinion, the behavior of a big system can be mimicked by combining detailed submodels. These concepts are discussed in the paper.

Chapter 7 presents a number of problems in ecosystem simulation, e.g. simulating temporal fluctuations, quantifying energy and material flows, compromising mathematical perfection to data imperfections, etc., based on the study of a cryptozoan community of the forest floor.

In Chapter 8 the authors treat the question, whether the newer methods of system ecology can be used in connection with the older data and observations of traditional synecology.

In the last two chapters (9 and 10) we can see the process of model building and developing from the simplest one to the most proper one, following the steps outlined in Chapter 1. The final model constructed by the author (in Chapter 10) has more of a pedagogical value, than an analytical one, presenting the successive levels of model building in details and well discussed. The work is based on the classical works of LINDEMAN.

Volume II.

The second volume contains 12 chapters grouped in four parts.

Part I.

The single chapter in Part I. is an introduction to system science, but is not identical with Part I. in Vol. I., having new questions, such as the role of the observer, characterization of objects, etc. Of course, there is some overlapping, too.

Part II.

Two chapters are included in it. They treat two kinds of analysis, the sensitivity analysis and the frequency one, Chapter 2 and 3, respectively. The former is outlined briefly, the latter is outlined in a more detailed form.

Part III.

The five chapters presented in this part represent consistent and basic sets of formal characterizations of some main themes in system ecology. They are "theoretical" and so would seem to be prosaic and abstract, and in some cases difficult to read. But, they are essential for understanding the problems and for building useful models.

In Chapter 4 the symbolic language used for describing energy systems is presented. This language combines energy laws, principles of kinetics, some philosophical tenets of electrical systems.

Chapter 5 deals with the feasibility of several nonlinear formulations in compartment modeling of ecosystems. It investigates whether a mathematically and ecologically satisfactory

steady state does exist having all compartments and flows real, positive and final values. Not all nonlinear systems can serve as a model for natural systems as it is indicated here.

Chapter 6 concerns the connectivity in systems. In an ecological context it means the problem of food webs. The theory of mathematical graphs is used to investigate the characteristics of food webs (the maximum number of links in a web, the maximum length of a chain, the trophic partition, subwebs, etc.).

Chapter 7 takes up the important topic of ecological niche, one of the most elusive concepts in ecology. The study approaches the problem of ecological niche from the point of bird habitat selection. The goal was to develop and utilize a quantifiable geometric niche model of species. Three niche measures were used, the measure of realized niche, and two measures of fundamental niche, that is the niche width and the niche overlap. These measures were used to construct niche patterns. The ability of the niche pattern concept to characterize the niche structure suggests a wider application. Hypothetical niche patterns were constructed to compare several communities.

Part IV.

Five chapters are included in this section. They present some possibility of system ecology applications.

Chapter 8 deals with the problem of fisheries. The material of this chapter suggests that the methods of system analysis are potentially valuable for a better understanding and solution of the problems of fishery.

In Chapter 9 the author gives a review of the current status of computer simulation modeling in applied ecology. There area lot of examples with biological or with bioeconomical goals, chiefly from the topic of fishery.

Chapter 10 is devoted to uses of system concepts and methods in courtroom environmental defences. The different ways that system studies can be used in court action are brought out.

Chapter 11 treats system ecology and the future of human society. Man is tied to a global ecosystem and planning for survival means finding ways to handle the complexity. Much of the chapter is devoted to the CALSIM (California Simulation) project, a team study to explore the feasibility of developing a model of social economic and ecologic aspects of the state of California.

In Chapter 12 the brief history and current status of ecological modeling are reviewed and the growth of interest and activity are stated and documented. The trend from individual efforts to interdisciplinary teams is indicated. Moreover a few "next generation" ecomodels are outlined, as well. Of particular interest is the extension of ecology to the spheres of human personality and interactions. The author regards ecology as a valid perspective on all large man-nature systems.

J. N. Nosek

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ACTA BOTANICA

ТОМ 23. ВЫП. 3–4

Резюме

ЗАМЕЧАНИЕ О КУБИНСКИХ ACANTHACEAE I. OPLONIA И ELYTRARIA

А. БОРХИДИ, О. МЮНИЦ

В настоящей работе обсуждаются некоторые таксономические проблемы рода *Oplonia* Raf, дается новый ключ к определению растений этого рода, а также описывается 4 новых вида и 1 подвид (*O. moana* sp. n., *O. cubensis* sp. n., *O. multigemma* sp n., *O. Acunae* sp. n., *O. spinosa* ssp. *insularis* ssp. n.) и дается дополнительное описание некоторых видов *O. nannophylla* (Urb.) Stearn., *O. tetrasticha* (Wr. ex Griseb.) Stearn., *O.polyece* (Stearn) Borhidi. Во второй части статьи находится ключ к определению кубинского рода *Elytraria* Michx., а также описание двух новых видов и одного нового подвида (*E. spathulifolia*, sp. n., E. *filicaulis* sp. n., *E. planifolia* ssp. *Acunae* ssp. n.) и в конце описывается вид *Stenandrium* (*S. heterotrichum* sp. n.)

СУПРАИНДИВИДУАЛЬНАЯ ГОМОГЕННОСТЬ ФОТОСИНТЕТИЧЕСКИХ ПИГМЕНТОВ. УЧЕНИЕ О СТРУКТУРЕ СООБЩЕСТВА

Г. ФЭКЭТЭ, З. ТУБА

Авторы исследовали содержание фотосинтетических пигментов (хлорофилла и каротиноида) на трех уровнях в лесу *Quercetum petraeae-cerris*. Разделение пигментов производилось методом тонкослойной хроматографии. Вместе с видовыми-индивидуальными образцами авторы анализировали и супраиндивидуальные образцы видов, составляющих уровни. Цель: можно ли считаться с регуляцией, действующей на супраиндивидуальном уровне, которая влияет как гомогенизатор на биохимическую структуру. Взятие образцов происходило в четырех повторностях, как из видов, так и из смешанных образцов. Оценка полученных данных основывалась на отклонении данных, вернее на сходстве повторностей и на разнообразии пигментов.

На основе отклонения общее содержание хлорофилла в кустарниковом и травянистом уровне более гомогенное, чем у их компонентов (видов), а лиственная крона деревьев занимает промежуточное место между двумя видами дуба. На основе релятивной фреквенции шести пигментов (хлорофилл а, хлорофилл б, каротин, лутеин и антераксантин вместе, виолаксантин, неоксантин) полученные эвклидные расстояния показывают, что крона листьев и травяной уровень, как супраиндивидуальная единица более гомогенная, чем отдельные компоненты. Если примем во внимание, выраженное формулой Shannon разнообразие пигмента, тогда все три уровня более гомогенны, чем отдельные виды. Верхний и нижний уровень леса, а в особенности фиксированная пигментная структура травяного уровня говорит о гомеостазе, который супраиндивидуально регулируется.

ВИДОВОЕ РАЗНООБРАЗИЕ ВОДОРОСЛЕЙ В ДВУХ РЫБНЫХ ОЗЕРАХ II. ЧАСТЬ. НЕ ВИДОВОЙ УРОВЕНЬ

Л. ХАЙДУ

Программа разнообразия, проведенная гипотетическим набором данных подтвердила, что большая часть индексов очень чувствительна к величине образца, и это значит, что для алгологии не подходит. В дальнейшем автор использовал только *H', J, S*. В статье дается объемная биомасса видов водорослей. Разнообразие, вычисленное из данных инди-

видуальных и обьемных коррелирует в неудобренном озере, а в удобренном озере нет корреляции. Этот последний факт — более низкая равномерность — произошел в первую очередь из-за данных абсолютно доминантного вида. Разнообразие, вычесленное из объемных данных еще более отстало от возможности максимума, что было замечено у индивидуальных данных, и эта тенденция более выражена в удобренном озере. Озера богаты этим родом (на один род приходится 2,3 инфрародовых таксонов), и поэтому разнообразие степени рода в основном не отличалось от видовой. Однако, на уровне дивизии была отмечена значительная потеря информации. Вместе с разнообразием всех водорослей единственно только доминирующее квантативно разнообразие дивизии *Chlorophyta* коррелировало сигнификантно.

ТЕРАТОЛОГИЧЕСКИЙ АППАРАТ ГОЛЬДЖИ В КЛЕТКАХ МЕЗОФИЛЛА ЛИСТА SINAPIS ALBA

И. ХОРВАТ, М. БОЛДОЦКИ

Авторы изучали электронномикроскопическую структуру среза мезофилла листа белой горчицы, которая отличается от известной структуры клеточных органелл. Растения были в возрасте 5 недель, препарат был изготовлен из 6 листьев. Фиксация производилась в OsO_4-глютаральдегиде. Структуру можно было хорошо определить, она состояла из тубулусов и везикулумов и исключала артэфакты. По структуре, размеру и из-за отсутствия рибосом можно предположить, что структура аппарата Гольджи имеет деформированную и тератологическую форму.

ОРГАНИЗАЦИЯ СТРУКТУРЫ И СВЯЗЬ МЕЖДУ НЕКОТОРЫМИ ОРГАНАМИ У ВЕНГЕРСКИХ ВИДОВ GENTIANA

Ю. СУЙКО-ЛАЦА, СУБИР СЕН

В предыдуших статьях авторы (Суйко-Лаца, Сен 1976) выяснили, что в Венгрии произрастает три вида ***Gentiana*** (***G. asclepiadea***, ***G. cruciata***, ***G. pneumonanthe***). В данной статье авторы изучали композицию этих трех видов, а также объемное отношение и распределение отдельных органов. Таксономические описания относятся к цветущим, но не совсем развитым экземплярам (Фролих 1786, Гризебах 1839, 1843, Кузнецов 1896) так, как в случае видов ***G. cruciata*** и ***G. pneumonanthe*** тоже отсутствует описание боковых побегов. У ***G. cruciata*** на главных побегах в акропетальном порядке развиваются и боковые побеги, считая с половины время цветения (около трех месяцев, растение с множеством побегов). В случае ***G. pneumonanthe*** появление боковых побегов возможно. Длина междоузлий показывает нормальное распределение у ***G. cruciata*** и у ***G. asclepiadea*** у ***G. pneumonanthe*** междоузлия растущие-уменьшающиеся, потом снова растущие-уменьшающиеся. Между числом узлов и длиной побегов у ***G. ascleepiadea*** и ***G. cruciata*** а у ***G. pneumonanthe*** между изменением числа длины междоузлий и длиной побегов имеется позитивная сигнификантная корреляция. Подобным позитивно коррелирует друг с другом логарифм длины главного побега и бокового побега у ***G. cruciata***. В корреляции друг с другом находятся значение длины влагалища листа и порядковый номер узлов у ***G. cruciata***. Появление боковых побегов ***G. cruciata*** показывает большое разнообразие и низкую эквитабильность по порядковому номеру узла. Значение фреквенции длины побега показывает более высокую степень разнообразия у ***G. asclepiadea***, чем у ***G. cruciata***. ***G. pneumonanthe*** выделяется высокими оценками разнообразия и эквитабильности числа узлов, несущих цветы.

ИССЛЕДОВАНИЕ ВЕРТИКАЛЬНОЙ СТРУКТУРЫ ПИГМЕНТА В ЛЕСУ ИЗ БУРГУНДСКОГО ДУБА (QUERCETUM PETRAEAE-CERRIS)

З. ТУБА

Автор исследовал вертикальное разделение фотосинтетических пигментов хлорофилла и каротиноида внутри ценоза на территории стационара «**Sikfőkút Project**» на уровне трех главных продуцентов. В сообществе нашли хорошо выраженное вертикаль-

ное разделение пигмента. Для вертикальной пигментной структуры лесного сообщества характерно, что на самом низком уровне ценоза, в связи с понижением количества света, проникающего вертикально вниз, имеются высокие величины концентрации хлорофилла и каротиноидов. Понижение отношения хлорофилла а и б на кустарниковом уровне и на травянистом уровне по отношению к лиственной кроне возможно находится в связи со спектральным изменением света при проникновении его с высшего уровня. Среди главных уровней продуцентов самое большое количество пигмента (выраженного в кг) LAI локализируется в кроне листьев, в то время как в кустарниковом уровне летом, а в травяном уровне—осенью находится большое количество пигмента.

АНАТОМИЯ ДРЕВЕСИНЫ BOMBACOPSIS CUBENSIS A. ROBYNS (BOMBACACEAE) И MAGNOLIA CUBENSIS URB. SSP. CUBENSIS (MAGNOLIACEAE)

М. А. ВАЛЕШ, К. БАБОШ, А. БОРХИДИ

В статье даются данные по анатомии вторичных ксилем двух кубинских эндемических пород древесины. Авторы дают некоторые морфологические и экологические данные этих видов.

ВЛИЯНИЕ КСЕНОБИОТИЧЕСКОЙ ИНТЕРАКЦИИ НА КСЕНОБИОТИКИ И ПОЧВЕННУЮ МИКРОБИОТУ VI СИМБИОЗ РИЗОБИУМА И ЛЮПИНА И КОМБИНАЦИИ ГЕРБИЦИДОВ

М. КЕЧКЕШ, Ф. БОРБЕЙ, И. БОРБЕЙ

Авторы исследовали влияние 108 гербицидов их комбинаций на образование корневых клубьеков у *Lupinus albus* в богатых ризобием культурных экосистемах. Обыкновенно макросимбионт был более чувствителен к гербицидам, чем микросимбионт. Подавление симбиоза *Lupinus albus—Rhizobium lupini* начался в главных корнях и проявился в уменьшении корневых клубеньков, в их размерах и количестве. Комбинации из **Karmex—Afalon-Sadecid** привели к хорошим результатам с точки зрения химического уничтожения сорняков в культурах *Lupinus albus*.

СВЯЗЬ МЕЖДУ ХАРАКТЕРИСТИКАМИ АНАЛИЗА РОСТА У ГИБРИДОВ КУКУРУЗЫ И СОРТАМИ САХАРНОЙ СВЕКЛЫ

И. ПРЕЧЕНЬИ

Автор провел «principal component» анализ между характеристиками анализа роста (*RGR, NAR, LAR, RLGR, LAI, CGR* и эффициенции), на основе корреляционного матрикса с двумя генетически различными гибридами кукурузы (*DKXL-342* и *OSSK-218*) (*Beta poly M/102* и *Kawemono*) и двумя сортами сахарной свеклы. Цель этих исследований: возможно ли выявить такой фактор, на который одинаково реагируют характеристики анализа роста двух культивированных растений, произрастающих в различных условиях. Вернее возможно ли найти такой фактор, который характерен только для отдельных видов. Первый компонент гибридов кукурузы содержит такой фактор, который одинаков для них. Это можно считать общим фактором. Второй компонент разделяет гибриды, это генетический фактор. Так как фактор, находящийся в первом компоненте не разделяет генетически различные гибриды и отличается от обнаруженного до сих пор у сахарной свеклы фактора, можно считать, что он характерен для кукурузы. Точно также у видов сахарной свеклы первый компонент может содержать фактор, характерный для сахарной свеклы. У сортов сахарной свеклы нет разделяющего фактора. Знаки вес *RGR, RLGR, RGR, NAR* и эффициенции одинаковы для некоторых компонентов у обоих растений (исключая один случай с гибридами кукурузы). Фактор влияющий на *RGR*, одинаково влияет на *RLGR* и на эффициенцию, фактор, влияющий на *NAR* также влияет на эффициенцию. *LAR* и *LAI* у растений противоположно влияет на все факторы, их никогда невозможно найти на одина-

ковых местах оси. Выше упомянутый факт говорит о сходстве между различными растениями. Кажется, что несмотря на то, что автор работал с растениями, произрастающими в различных условиях, имеются такие факторы, на которые одинаково реагируют характеристики анализа роста. Для оценки результатов надо принимать во внимание то, что эти результаты действительно только в выбранной системе.

ПРИМЕНЕНИЕ АНАЛИЗА NICHE ДЛЯ НЕКОТОРЫХ ВИДОВ ПЕСЧАННОСТЕПНЫХ АССОЦИАЦИЙ III ИЗУЧЕНИЕ NICHE OVERLAP С ПОМОЩЬЮ АНАЛИЗА CLUSTER

И. ПРЕЧЕНЬИ, Г. ФЕКЕТЕ, Э. МЕЛКО, Э. МОЛЬНАР

Авторы изучали летом и осенью **niche-overlap** у девяти травянистых видов песчанностепных ассоциаций в двух измерениях **niche** (влажность почвы, глубина корней, вернее комбинацию этих измерений). Эта статья предлагает дальнейшее анализирование **overlap** с введением анализа **cluster** Для оценки **overlap** авторы используют эвклидное расстояние между видами, **(chord distance, *d*)**, вернее формулу **(2-d^2)** (Орлоци;1967). Анализ **cluster** проводился на основании **average linkage clustering.** Летние и осенние дендрограммы можно сопоставить друг с другом: между ними сходство больше по сезональности и влажности почвы, а по глубине корней сходство меньше, комбинирование факторов занимает промежуточное место. Дендрограммы также свидетельствуют о более раннем определении авторов, что картина **overlap** при комбинировании факторов стоит ближе к картине **overlap** глубины корней.

СИСТЕМАТИЧЕСКИЕ-НОМЕНКЛАТУРНЫЕ ПРИМЕЧАНИЯ К КРИТИЧЕСКИМ ТАКСОНАМ СРЕДНЕЕВРОПЕЙСКОЙ ФЛОРЫ

Р. ШОО

Автор, продолжая свои ранние исследования (**Acta Bot. Hung.** 1963—1971, **Annal. Univ. Budapest Sect. Biol.** 1964—1972 с сотрудниками и **Feddes Repetorium** 1972, 1974) сообщает новые систематические-номенклатурные данные, полученные при составлении 6 тома, **Synopsis... Florae Vegetationisque Hungariae.** Можно отметить: новую систематическую оценку экотипов, обзор некоторых критических форм или агрегатов, в особенности принимая во внимание группы ***Jovibarba hirta***, ***Fraxinus angustifolia***, ***Leucanthemum vulgare***, ***Scilla bifolia*** и т. д.

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